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Proceedings of the Twenty-first Indian Science Congress

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General.

The twenty-first meeting of the Indian Science Congress Association was held at Bombay from January 2nd to 8th, 1934.

The inaugural meeting was held on Tuesday, January 2nd, 1934, at 5 P.M. in the Convocation Hall of the Bombay University. Mr. V. N. Chandavarkar, B.A. (Cantab.), Bar.-at-Law, Chairman of the Local Reception Committee, and Vice-Chancellor of the Bombay University, welcomed the delegates in a short speech and requested the Patron, H.E. the Right Honourable Michael Herbert Rudolf Knatchbull, Lord Brabourne, G.C.I.E., M.C., Governor of Bombay, and Chancellor of the Bombay University, to open the Congress. The President of the Congress, Prof. Meghnad Saha, D.Sc., F.R.S., F.A.S.B., then delivered his address.

THE SECTIONAL PRESIDENTIAL ADDRESSES WERE DELIVERED AS FOLLOWS :—

WEDNESDAY, *3rd January*, 10 A.M., Mathematics and Physics ; 11 A.M., Agriculture ; 12 NOON, Botany.

THURSDAY, *4th January*, 10 A.M., Geology ; 11 A.M., Zoology ; 12 NOON, Medical and Veterinary Research.

FRIDAY, *5th January*, 10 A.M., Chemistry ; 11 A.M., Anthropology ; 12 NOON, Psychology.

SYMPOSIA AND JOINT MEETINGS OF SECTIONS WERE HELD AS FOLLOWS :—

WEDNESDAY, *3rd January*, 11 A.M., Symposium on 'Neutrons, Positrons, and Cosmic Rays', Section of the Mathematics and Physics. 2 P.M., 'Chemical Researches in India and their bearing on Technical Problems', Section of Chemistry.

THURSDAY, *4th January*, 10 A.M., 'Recent Work on Plant Genetics done in India', Sections of Agriculture and Botany.

FRIDAY, *5th January*, 11 A.M., 'Recent Advances in Colloid Chemistry', Section of Chemistry. 2 P.M., Joint meeting of the Sections of Agriculture, Mathematics and Physics, Chemistry, Botany and Geology, to consider the advisability of starting a National Section of the International Society of Soil Sciences.

THE POPULAR LECTURES WERE DELIVERED AS FOLLOWS :—

January 2nd, 7 P.M., 'Architecture of the Heavens', by Dr. D. S. Kothari, Allahabad.

January 3rd, 6-30 P.M., 'The Expanding Universe', by Prof. A. C. Banerji, I.E.S., Allahabad.

January 4th, 6-30 P.M., 'Recent Agricultural Developments in Europe and America', by Dr. S. S. Nehru, I.C.S., Fatehpur, U.P.

January 5th, 6-30 P.M., 'Is Darwinism Dead ?', by Prof. R. H. Dastur, Bombay.

January 6th, 6-30 P.M., 'Electrical Transmission of Pictures', by S. R. Kantabet, Esq., Bombay.

January 8th, 6-30 P.M., 'Physiology and Human Welfare', by Major S. L. Bhatia, I.M.S., Bombay.

THE FOLLOWING FUNCTIONS AND ENTERTAINMENTS WERE HELD IN HONOUR OF THE MEMBERS OF THE INDIAN SCIENCE CONGRESS :—

TUESDAY, *2nd January*, 10 P.M.–11-30 P.M., Screening of Selected Reels of Indian Talkies by the Motion Picture Society of India (Sir C. J. Public Hall, R.Inst. of Science).

WEDNESDAY, *3rd January*, 5 P.M., 'At Home' by the Local Reception Committee (University Gardens).

10 P.M.–11-30 P.M., Screening of Scientific Films by the Deputy Director of Visual Instruction, Bombay Presidency (Sir C. J. Public Hall).

THURSDAY, *4th January*, 4-30 P.M., 'Garden Party' at the Government House, Malabar Hill.

10 P.M.–11-30 P.M., Screening of Technical Films by Messrs. Krupp India Trading Co., Ltd. (Sir C. J. Public Hall).

FRIDAY, *5th January*, 5 P.M., 'Garden Party' by Messrs. Gordhandas, Desai and Co. (University Gardens).

10 P.M.–11-30 P.M., Soiree of Indian Music and Dance by the Indian School of Music and Menaka's Troupe of Dancers (Sir C. J. Public Hall).

SATURDAY, *6th January*, 4-30 P.M., 'At Home' to the Members of the Botany Section by the Staff and Post-graduate Students of the Botany Department of the Royal Institute of Science.

4-30 P.M., 'At Home' to Members of the Chemistry Section by the President and Fellows of the Bombay Branch of the Indian Chemical Society.

10 P.M.–11-30 P.M., Screening of Educational Films by Messrs. Agfa, Kodak, and Phillips (Sir C. J. Public Hall).

THE FOLLOWING VISITS AND EXCURSIONS WERE ARRANGED FOR MEMBERS OF THE INDIAN SCIENCE CONGRESS :—

WEDNESDAY, *3rd January*, 2 P.M.–5 P.M. :—

(1) Grant Medical College and attached Hospitals, Byculla.

(2) Gordhandas Sunderdas Medical College and allied Hospitals, Parel.
(3) Bai Jerbai Wadia Hospital for Children, Parel.
(4) Nowrosji Wadia Maternity Hospital, Parel.
(5) Haffkine Institute, (bacteriological), Parel.
(6) Veterinary College, Parel.
(7) G.I.P. Railway Workshops, Parel.
(8) Bombay Soap Factory, Byculla.
(9) The Automatic Telephone Exchange.
(10) The Docks.
(11) Indian Smelting and Refining Company's Works, Mazgaon.

THURSDAY, *4th January*, 2 P.M.–4-30 P.M. :—

(1) The Mint.
(2) Calculating Machines of the Oriental Life Assurance Company's Offices.
(3) Swadeshi Electric Clock Company's Works, Tardeo Road.
(4) Broadcasting Studio and Station, Ballard Estate, and Worli.

FRIDAY, *5th January*, 2 P.M.–5 P.M. :—

(1) School for the Blind and other defectives.
(2) Tidal Model of the Bombay Port.
(3) G.I.P. Railway Workshops, Matunga.
(4) Victoria Jubilee Technical Institute, Matunga.
(5) Cotton Research Laboratory, Matunga.
(6) Bombay Gas Company's Works.
(7) Pearl Testing Laboratory.
(8) Ajanta Cinetone Company's Studio.
(9) Victoria Gardens and Albert Museum.
(10) The Prince of Wales Museum.

SATURDAY, *6th January*, 2 P.M.–5 P.M. :—

(1) Meteorological Observatory, Colaba.
(2) Electric sub-station of the Tata Power Co., Ltd., Dharavi.
(3) Kandivali Glass Bangle Factory.
(4) Ismail College, Rubber Factory, and Caves, Jogeshwari.
(5) Times of India Press.
(6) Lightfoot Refrigerating Company.
(7) Sound Studios (India), Ltd., Tardeo.
(8) Bharat Tiles Co., Uran (By Motor Boat).
(9) Air-conditioning plant at the Regal Theatre and Show.
(10) The Swadeshi Market Museum.

WEEK END EXCURSIONS (SATURDAY, *6th January*, to MONDAY, *8th January*) :—

Poona : Educational, Scientific, and Industrial Institutions.
Bhatghar : The Lloyd Dam.
Bhor : Reception at the Palace of the Chief of Bhor.

SUNDAY EXCURSIONS, *7th January* :—

(1) Alibag : Magnetic Observatory.
(2) Elephanta : Elephanta Caves.
(3) Geological Excursion to Salsette.
(4) Excursion to places of Botanical interest in Salsette.
(5) Zoological Excursion.

MONDAY, *8th January*, 8 A.M., Excursion for Tata Hydro-Electric Power Station at Khopoli, and Walwpan Lake at Lonavla.

The COUNCIL of the Indian Science Congress met at 3 P.M. on the 2nd January, 1934.

The SECTIONAL COMMITTEES met at 12 NOON on the 2nd January, 1934.

The EXECUTIVE COMMITTEE met at 2 P.M. on the 3rd January, 1934.

A special meeting of the GENERAL COMMITTEE was held at 9 P.M. on the 3rd January, 1934, to discuss proposals regarding the formation of an Indian Academy of Sciences.

The Meeting of the GENERAL COMMITTEE was held at 2-30 P.M. on Friday, 5th January, 1934.

Opening Proceedings.

The twenty-first session of the Indian Science Congress was opened on Tuesday, 2nd January, 1934, at 5 P.M. Mr. V. N. Chandavarkar, B.A., Bar.-at-Law, received the Patron, H.E. the Rt. Hon'ble Michael Herbert Rudolf Knatchbull, Lord Brabourne, at the entrance of the Convocation Hall and introduced him to the President who introduced the Presidents of Sections and Officers of the Indian Science Congress to him. After a short opening speech by the Patron, the President, Prof. Dr. M. N. Saha, delivered his address.

At the conclusion of the address, Mr. V. N. Chandavarkar proposed a vote of thanks to H.E. the Governor of Bombay, for having consented to open the Congress, which was carried by acclamation.

Presidential Address.

Congress President :—PROF. M. N. SAHA, D.SC., F.R.S., F.A.S.B.

FUNDAMENTAL COSMOLOGICAL PROBLEMS (WITH TWO APPENDICES).

YOUR EXCELLENCY, LADIES, FELLOW-SCIENTISTS, AND GENTLEMEN,

I.

The return of the Indian Science Congress to Bombay for the third time after the lapse of eight years bespeaks of the large-hearted liberality for which the citizens of Bombay have been distinguished. On this occasion, specially on behalf of the scientists assembled here, I have to convey to the hosts our heart-felt thanks for the ready response which they made to our call of distress. I have further to remind my colleagues that to-day at Bombay the Science Congress attains the legal age for majority, when we shall be quite within our rights to claim for the congress, from the state as well as from the public, those rights and privileges which are enjoyed by similar associations in other countries of the world. But of these demands, I shall speak only during the concluding parts of my address.

In 1925, the occupant of the Presidential Chair was Mr. Howard, well known for his valuable contributions to *Indian Agriculture*. The present speaker cannot claim to have been so useful to the public. In 1925, while presiding over the Physics section at this very city, he occupied himself with the rather abstruse topic of application of recent advances in Physics to the study of the heavenly bodies. It is rather regrettable that even in a place like Bombay which is a city of pragmatic philosophers, the speaker has not been able to change to a subject having a more human appeal. On the contrary, he wishes to start from the point where he left on the last occasion and deal with the story of the universe of which we form an organic, though insignificant, part. The subject has been chosen for a variety of reasons: first, the speaker is personally interested in it; secondly, as a cultural subject, it led to the emancipation of the human mind during middle ages, when Copernicus deposed the Earth from its proud position of being regarded as the centre of the Universe. This stimulated men in Western Europe to further fields of exploration and ultimately led to the development of modern science; thirdly, in India, in spite of our traditional boast of caring for knowledge for the sake of knowledge alone, the claims of pure science are being sadly neglected for subjects of utilitarian value; lastly, because it had so far no exponent in the chair which I have the honour and privilege of occupying to-day.[1]

THE CREATION MYTHS.

At the outset I would remind you that like all other higher activities of the human mind, scientific activity is based on faith . . . the faith in the reality of an external world, independent of the idiosyncrasies of the participant subject (the human mind). Scientific knowledge therefore claims to be objective, knows no limitation of race, country or age and has been built up by the united labour of past and present generations of mankind. These remarks apply all the more strongly even to our subject which can be traced to the remotest antiquity; it is certain that even in the primitive savage stage, when man must have spent most of his existence in caves for fear of wild beasts and departed spirits, he must have stolen occasional glances at Nature: at the smiling Earth teeming with fruit, flower and game; the life-giving Sun in all his majesty; the Moon with her soothing rays; rain and cloud with occasional thunders and the blue firmament with its inlaid stars and their mysterious motions; nothing seems to have stirred the human imagination so much as these phenomena of Nature. When civilization developed and man felt the necessity of defining his relation with fellow-men and with the surrounding world, he was led to ponder over all these phenomena of the sky, and was led to weave cobwebs of mystic cults of gods and spirits, and construct labyrinths of metaphysics in which the heavenly bodies played a conspicuous part.

It is a remarkable fact with almost every civilization, that the sages of ancient times were constrained to construct a story of Creation. This points to a fundamental trait of the human mind from which, I submit, that even the modern man has not been able to free himself: that man feels himself to be a part of the Universe and is anxious to know his position in the Universe. Take for example the following creation myth of the ancient Sumerians who conceived that the world had sprung out of water; and the gods who were mostly identified with heavenly bodies stood for order.

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[1] A well-known scientist of India once remarked in a public lecture that astronomy has never been of any practical use to mankind. He seems to have forgotten that the greatest event of medieval times, the discovery of America and circumnavigation of the world would have been impossible without a knowledge of astronomy and even to-day, without knowledge of astronomy navigation is not possible.

When on high, heaven was not named,
Below, dry land was not named,
Apsu, their first begetter,
Mummu and Tiamat, the Mother of all of them
Their Waters combined together.
Field was not marked off, sprout had not come forth
When none of the Gods had come forth
Had not borne a name,
No names had been fixed
The Gods were created in the midst of heaven.

The story then goes that man was created for doing homage to the gods.[1]

Later Jewish theology, which still finds currency in many Christian countries even to-day, regarded man as created in the image of God, in a spirit of rather vainglorious exaltation of man.

THE NEW CREATION STORIES—THE NEBULAR HYPOTHESIS.

In all old creation myths, the creation of the organic world of life and of the physical world were hopelessly mixed together. But after the discovery of the knowledge that the Earth is an insignificant planet in the train of a second-rate star which is only one of a numberless multitude, and man is only the culmination of forms of life which came into existence, flourished and died out in the successive geological epochs, the old creation myths became untenable. It was Immanuel Kant, the great surveyor of human knowledge in the eighteenth century, who first drew a clear-cut line between the organic and the inorganic worlds. In his 'Anthropology' the possibility of animal origin of mankind was suggested in words which smack of Darwinism. But the same Kant also undertook a survey of the Inorganic World in his 'Theory of Heavens' which was later elaborated by Laplace into the famous Nebular Hypothesis. In fact, Kant and Laplace attempted a mechanical explanation of the origin and motion of planets and their developments out of a primeval Nebula or fog of vast dimensions.

The next great Evolutionist on the physical side was Sir Norman Lockyer who sketched his ideas in numerous papers and publications culminating in a book on 'Inorganic Evolution' published in 1900. The story of creation as constructed by Kant and Laplace was an attempt at a synthetic view of the world as revealed by the new knowledge which was acquired by mankind since Copernicus gave out his heliocentric theory of the world, and the laws of planetary motion were discovered by the successive labours of Kepler, Galileo, and Newton, and perfected by Laplace, Lagrange and other mathematicians. Up to the time of Kant, man's interest had not yet outgrown the solar system. The stars were still objects of curiosity. But by the earlier part of the nineteenth century, Bessel and Henderson perfected the parallax method of determining the distances of stars, and Lord Rosse, in his great telescope first saw in 1845, the Nebula in spiral motion as mentally pictured by Laplace and Herschel. The discovery of photography and of Spectrum analysis in 1859 by Kirchhoff provided the astronomers with the necessary means of undertaking the physical and trigonometric survey of heavens on a scale which could not be dreamt of by the previous generation of astronomers.

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[1] The belief still persists, for Bishop Barnes writes: 'The religious outlook of many of us is determined by our belief that God has created man for his Service.'—*Nature,* 130, 721.

LOCKYER'S THEORY OF INORGANIC EVOLUTION.

Regarding Lockyer's theories, I can do no better than quote from an article which I contributed to the Sir Norman Lockyer Memorial Volume : ' Lockyer was called to astronomical work by Kirchhoff's profound discovery of spectrum analysis (which placed in the hands of astronomers an instrument of unrivalled power and potency for surveying the physical nature of the sun, stars). (After Sechhi in Italy and Huggins in England) Lockyer was one of the first to set to himself the task of exploring the Sun and the stellar universe with the new instrument on a large scale. He obtained results for which the existing theories or ideas were quite insufficient ; he initiated laboratory work for elucidating these results. The confusion became worse confounded. He had to formulate theories of his own which were a direct challenge to the accepted theories of those days and for which the scientific world was the least prepared.

For, in those days, it was almost universally held that the atom was the ultimate constituent of all matter. It was held that like a tuning-fork, the atom could be made to emit only a few simple notes, i.e. spectral lines which were invariable. But Lockyer's experience of stellar spectra and spectra of elements in the laboratory told him that these ideas were not only insufficient but also misleading. He found that by subjecting elements to varying stimuli, the nature of the spectrum could be varied within wide limits. A very good example is afforded by calcium, which gives a line called by Fraunhofer g, λ 4227 ; this line is very strong in the flame and in the arc, but fades in the spark. On the other hand, two other lines, the H and K of Fraunhofer, which are faint in the flame, become prominent in the arc and completely dominate the spectrum of the spark. Lockyer found similar results in the spectra of other elements, and in the case of silicon he found no less than four successive stages. If the atom was invariable, argued Lockyer, how could these variations be accounted for?

Lockyer was first and foremost a pioneer explorer of the stellar world, and the laboratory work of which we have just spoken was undertaken in order to obtain a clear explanation of the phenomena which he had discovered in a systematic study of the spectra of the Sun and Stars.

He had discovered that these spectra could be arranged in a number of well-marked groups, which by gradual steps merge into each other. This classification was confirmed in essential points by the spectroscopic survey of 200,000 stars at the Harvard College Observatory by Professor Pickering and Miss Cannon. They denoted these groups by the letters

N — M — K — G — F — A — B — O — P

Lockyer found that the spectra of red and yellow stars mostly consisted of arc lines, while in the spectra of white stars the metallic lines became fainter, and the enhanced lines became more prominent.'

DECODING THE MESSAGES—THE IONISATION THEORY.

Lockyer's speculations were rather in advance of his times. Icarus-like, he wished to soar to the sun with, if one may be permitted to say so, wings of wax with the inevitable result. But it is clear that if we wish to learn more about the sidereal universe, we must be able to decode the messages which these distant bodies are sending to us in the form of light, for light is the only agency by which knowledge of these distant bodies can be conveyed to us. As mentioned already, an immense amount of these code messages in the form of spectra was collected by Lockyer, and other astronomers, particularly the Harvard group, but up to 1920, a satisfactory method of deciphering them was not known.

It is now a matter of history that in 1920, a method was obtained for the first time for decoding these messages. This consisted in the formulation of the ionisation theory and the theory of selective radiation pressure. The ionisation theory has given us a simple clue for tracing the changes in matter as the temperature is increased from laboratory values to those which we obtain in stars. It tells us that when the atoms are heated to higher and higher temperatures, the outermost electrons are knocked off one after the other, and the enhanced lines appear in greater strength. From the marginal appearance and disappearance of these lines, it is possible to calculate the temperatures and pressures of the outer atmospheres of the stars and form a general idea of the physical conditions prevailing in these bodies.

The theory of selective radiation pressure, which was formulated almost simultaneously with the ionisation theory, is a necessary supplement to the latter and it accounts, in a satisfactory way, for the existence of the stellar atmosphere. For on these heavenly bodies, the value of gravitation is sometimes so great, that unless this is counterbalanced by some other force, the atmosphere would collapse. But the theory of selective radiation pressure, further elaborated by Milne, showed that the force of gravity is counterbalanced by the pressure of radiation from the inside of the star. The radiation as it flows outwards is absorbed by the atoms. In this act, the quanta administer to the atom a forward kick which goes on multiplying owing to the number of acts of absorption per second. This simple theory has been shown to account in a satisfactory way for the anomalous distribution in stellar atmospheres of heavy elements like Calcium, Scandium, Titanium . . . . and absence of others, which appeared rather puzzling to the astronomer.

PHYSICAL SURVEY OF THE HEAVENS.

The successful application of the ionisation theory requires a complete knowledge of the structure of the atom, of their spectra in different stages of ionisation and a satisfactory theory of the intensities of spectral lines. At the time when the theory was first given, our knowledge of the atom was confined only to hydrogen though there were enormous masses of floating information about other atoms lying scattered in journals and special treatises. Within the last twelve years, all the information has been arranged into systematized knowledge, thanks to the activities, chiefly of the Bohr and Sommerfeld Schools of Physicists, so that now practically the lacunæ in our knowledge of the spectra of elements, which largely hampered the activities of the astrophysicist in 1920, have disappeared. This has enabled us to ascertain accurately the physical conditions in the wide variety of heavenly bodies which the astronomer comes across, planets and comets, giant and dwarf stars, planetary and diffuse nebulæ, interstellar matter, and extra-galactic nebulæ.

THE TRIGONOMETRIC SURVEY OF HEAVENS.

It is impossible to have a complete grasp of the cosmological problems unless one has some idea of the Geography of the Universe about us. Twenty years ago, exploration of space was hampered by the limitations of the parallax method, but the discovery of the cepheid variables provided us with lamp-posts with which exploration into undreamt-of depths of space has been rendered possible. To give an idea of the discoveries in this direction, I would ask the audience to take with me a trip to space with the velocity of light.

After the lapse of a second and half, we shall reach the moon which is our nearest neighbour and is at a distance $2{\cdot}4 \times 10^5$ miles. In eight minutes, we shall pass the *Sun*, the source of our light and life. In a few hours' time, we shall be past *Pluto*, our last neighbour in the solar system and then we shall meet with nothing of importance except dust and cosmic radiation for about four years. At the end of four years, we approach our nearest neighbour outside the solar family, *proxima Centauri* which is a faint star, radiating only 10^{-4} times the light of the sun and a little later her more powerful neighbours, the twin stars at α^- *Centauri.* After eight years, we make the acquaintance of *Sirius*, and of his still more wonderful companion of which we shall talk later. From the earth, Sirius appears to be the brightest star in the heavens and you may be knowing that owing to its brilliancy it excited innumerable stories and myths in the minds of all nations beginning from the old Egyptians. Sirius is not merely apparently bright, it actually emits twenty-nine times the light of the sun. After leaving Sirius, we cruise for 135 years, till we come to a rich field of luminaries which we have noted from the Earth. These are the famous *Pleiades* containing, to the naked eye, seven stars, but the telescope resolves the group into thousands. The Pleiades, on account of their striking appearance, have also like Sirius formed topics for numerous myths and legends. The size of this stellar colony is about 10^{19} cms., i.e. we shall take about ten years to traverse it from end to end. Close to it is another similar group called the *Hyades*. This cluster, unlike the Pleiades which contains only blue or white stars, is populated with stars of all colours. Clusters like the Pleiades and the Hyades are called *Galactic Clusters.* They are found distributed all along the *Milky Way* and we continue to meet them till we have been 4,000 years on our journey. When 10,000 years have passed, we are amidst Clusters of another type. These are much richer in stars than the richest of the Galactic Clusters and are in general found near the rim of the Milky Way. These are the *Globular Clusters.* About a hundred of them are known. In size a Globular Cluster is about ten times larger than a Galactic Cluster. The Globular Clusters mark the outer limits of our local *Galaxy*—also called the Local System. The local system forms an unit in a much bigger stellar organization which contains also the *Magellanic* clouds, a striking group of stars in the southern hemisphere called after the great explorer, Ferdinand Magellan, who observed them in his memorable first circumnavigation of the world. This is called the Galactic system or popularly the Milky Way which you can see on any clear night, as a luminous belt across the sky. The galactic system is about 10^{23} cms. in diameter and contains about 10^{10} individual stars. We shall have to cruise on monotonously for a hundred thousand years and then we are out of our galactic system. It will take us another million years before we reach a second galaxy which is our nearest neighbour—the *Spiral Nebula in Andromeda.* It is a giant amongst external galaxies, its longest diameter being a little over 40,000 light years. The Andromeda nebula is not a solitary system, but has associated with it two other fainter and smaller galaxies—the two forming a super-galaxy like the Milky Way. Several systems like our galactic system containing hundreds of galaxies have been found in the constellations Coma and Virgo. All the super-galaxies possibly form a larger organization which Shapley calls a *Metagalaxy*; and which to use Shapley's words is 'All comprehensive but still incomprehensible'. The *metagalaxy* is estimated to be about 10^{27} cms. in diameter. In exploring the distant regions of this metagalaxy, we shall have travelled for over many hundred million years and might, after so long a sojourn, feel tired of the monotony of infinity and inclined to give up the task of penetrating further into the endless depths of space. At this stage, we might gain some stimulus from the investigations of Einstein and others who say that space is not infinite but turns back on itself, like the skin of a football bladder. The Radius of the Einstein universe has been estimated at 10^{29} cms. with the hundred-inch telescope of Mt. Wilson, we can reach about one-sixth of this distance, but when the two hundred-inch telescope is completed we shall be able to reach double the distance. A time may come when we have reached the limit of the universe, then nothing but void will remain.

II. PROBLEMS OF EVOLUTION.

You will see from the foregoing sketchy account that the problems which an Evolutionist has to face to-day are much more imposing and complex than those confronting the famous scientists who were first bold enough to substitute old creation myths by the Nebular Hypothesis. You would like to know what is the present view regarding the Nebular Hypothesis. It is not possible to give a straight answer to this question, for the interest of Kant and Laplace was mainly confined to the solar system, while a present-day Evolutionist has to consider the whole Sidereal Universe of which the solar system forms but an insignificant part. We have further to define the meaning of the word 'Nebula'. Laplace used the term, if I may say so, in a truly nebulous sense, and it is regrettable that the bad habit is being still continued by the present-day astronomers. Anything which appears hazy in the telescope is indiscriminately termed a Nebula. But it is not difficult to perceive that haziness may be due to two distinct causes: (i) Physical haziness—because the substance is really composed of foggy matter. Such are planetary or diffuse nebulæ found in the Milky Way, which generally possess a star in its core. Density of matter in such nebulæ is probably not more than 10^{-17}—10^{-20} gms./cm.^{3} and far from being the Father of stars, it has now been ascertained that these nebulæ are due to some catastrophe which overtook the star in bygone days, when its outer shell was blown off, and gases were driven out with tremendous velocities forming the hazy envelope which is now called the nebula ; (ii) the second class comprises foggy masses like the Andromeda Nebula which are found outside the Milky Way, and are therefore known as Extra-galactic Nebulæ. Here the nebular appearance is merely visual, for due to enormous distance, the component stars are not resolved. It is only in recent years that these so-called nebulæ are yielding their secrets to the gigantic American telescopes as I have already described. Briefly speaking, they are distant galaxies, like our own Milky Way, composed of billions of stars in different stages of evolutions. In fact, to a resident on one of the planets in the Andromeda Nebula, our own Milky Way would appear as a huge spiral nebula, and the sun may appear as a fourteenth mag. star, provided the beings there have developed powers of exploration like ourselves.

As far as our present knowledge goes, the Universe consists of billions of galaxies distributed in space. But compared to the immensity of space, they are like little patches of oases of matter in a vast desert with huge distances intervening between each other. But it is probably not correct to say that there is absolutely no matter in the inter-galactic space. There is some evidence that while matter in the galactic spaces has a density of about 10^{-26} gm./cm.^{3} the density of matter in the spaces between neighbouring galaxies including our own Milky Way may be of the order of 10^{-31} gm./cm.^{3} The Nebulæ are found to possess a definite arrangement and are found rotating as a whole round definite axes.

Recently another very puzzling fact has been found. If the evidence of the spectroscope be correct, the galaxies are probably running away, from each other with tremendous speeds—in fact, the speed is found proportional to the distance, the value being 176 kms. per million light years. We have already likened the universe to the skin of a four-dimensional football. We have now to postulate that the football is expanding continuously, so that every point may be supposed to be receding from its neighbour with a speed which is proportional to their distance apart.

The problems which now confront the astrophysicist are as follows :—

(*a*) How do stars come into existence and what is their life-history ?
(*b*) How do they maintain their stock of energy ?
(*c*) What happens to the radiation which is being poured in space ?
(*d*) What is the ultimate fate of the Universe ?

THE LIFE-HISTORY OF A STAR.

Before dealing with the question of life-history of a star, it will not be out of place to indicate in brief how such a history has been compiled. The life of a star probably extends over billions of years. But as you all know, the span of human activity extends barely over forty years. Even the accumulated experience of mankind, the age of civilization, extends barely over a few thousand years. It is clear that these periods of time are too short to enable us to observe any substantial change in the appearance, position or luminosity of any single star. How do we then trace the life-history of a star ? The procedure followed by the astronomers may be illustrated by the following fine analogy due to Sir J. Herschel: 'suppose an intelligent observer who has never seen a tree is allowed one hour's walk in a forest. During this time, he will not see a single leaf unfold ; yet he could find sprouting seeds, small saplings, young, full-grown, and decrepit trees, and fallen trunks mouldering into earth, and in that brief hour he might form a correct idea of the life-history of a tree'.

What the astronomer does is exactly parallel. With his telescope and spectroscope, he finds out the distance, distribution, and temperature, density, composition and physical characteristics of as many stars as he can manage. Then he pieces together these data, tries to trace the chain of causation and effect, and endeavours to construct the full life-story of a stellar mass. It should however be remembered that the astronomer acts under very severe limitations. First, the power of his telescope is limited. It has been estimated that even with the 100-inch telescope of Mount Wilson Observatory in America we can barely reach one-seventh diameter of the Einstein World. Further, only comparatively big bodies which are hot enough to give visible radiation are picked up by the telescopes. Bodies which are small, or dark, escape the astronomer's attention altogether. And there may be more dark bodies in space than bright ones. The power of the spectroscope is still more limited. Owing to severe limitations of the photographic plate, and the absorption by our atmosphere we have to rely on an insignificant part of the electromagnetic spectrum, extending from λ 3000 to λ 6000 barely a region of one octave. But it is presumed that the radiation filling the space, range in wave-length from 10^{-14} cm. (Cosmic rays) to an unknown length which may be in the Hertzian region. This comprises about 45 octaves. The longer part of it, lying beyond 6000 A.U., gets lost partly due to insensitiveness of the photographic plate, partly due to absorption by our atmosphere. The waves shorter than 3000 all get absorbed by our atmosphere, excepting a short region beyond $4 \cdot 7 \times 10^{-11}$ cm. But in spite of this fact there is unmistakable evidence, that they do exist, and exert a profound influence on cosmic events.

The totality of our experience regarding the stars, which has been gained amidst these limitations is expressed in the well-known Russell-Hertzsprung diagram representing the total amount of light (luminosity) and the temperature of the stars as well as the frequency of occurrence of these stars but it is expressed in technical language which demands some explanation.

CONSTRUCTION OF THE LIFE-HISTORY.

From the above facts, the picture which the astronomer drew about the life-history of a star was as follows: A mass of extremely rarefied dark matter is supposed to go on contracting owing to the mutual gravitation of its parts. A stage is reached when the interior becomes exceedingly hot and the heat gradually spreads to the surface, till the temperature rises to a value when the surface begins to emit a dull red light. This is the stage marked by 'N' in the diagram. 'N' is a technical name denoting a star which appears fiery red to the naked eye, and which spectroscopic investigation shows to consist of an extremely dilute nebulous fog, at a temperature of about 3,000°C. The process of contraction goes on, and the inside of the star grows still hotter. But as radiation flows through the superincumbent envelope of matter, it is absorbed and exerts pressure on them. A considerable fraction of gravity is counterbalanced by the pressure of escaping radiation. This causes the process of contraction to slow down, and a consideration of the relations between total mass, density, and effective temperature shows that the limit of contraction is reached at a stage depending upon the total initial mass. A star of 10 to 12 times the mass of the sun can successively reach the stages denoted by the letters M, K, G, F, A, and B. These terms have some technical significance which is known only to a professional astrophysicist, but for the layman it will suffice to say that they are regions of higher surface temperatures and greater concentration. Stars M, K . . . . . appear red to the naked eye; G, F are yellowish, A and B are white. But the limiting stage which can be reached depends only on the initial mass. Thus a star having the same quantity of matter as our sun can at best reach the F-stage (surface temperature 8,000°C), while a star like Sirius having three times the mass of the sun may reach the B-stage (surface temperature 20,000°C). Once the maximum stage is reached the star will begin its downward career, i.e. the loss of energy by radiation will be larger than the evolution of energy due to contraction and other attendant processes. The star will become cooler and cooler until it ceases to emit light, and gradually passes out of sight.

According to this view, a star will have the same surface temperature twice in its life career: firstly, when due to contraction it is rising in temperature—at this stage the density is low and the surface is large. This is known as the *Giant stage*; secondly, when after reaching the maximum contraction, it radiates more energy than it gains by contraction. Now the density is very large, and the surface shrinks down to a moitie of its previous value. This is known as the *Dwarf stage.* The hypothesis of an ascending and descending stage in the evolution of a star was first suggested by Sir N. Lockyer on spectroscopic grounds, and was supported by Russell and Hertzsprung on the strength of a large amount of observational data.

On the theoretical side, the contraction of a gas sphere under the gravitational attraction was first treated by Emden, but Eddington was the first to consider the influence of radiation pressure on the process. Though these mathematical works suffer from the defect of having to take too many things for granted in which physical reality had often to be sacrificed for mathematical convenience, it yielded a result regarding mass and luminosity which was found to account for most of the facts observed up to 1921. One spectacular triumph of this view may be cited. Eddington and Russell predicted from these theories that the bright M-star α-Orionis (Betelgeuze) would have a diameter of $3{\cdot}4 \times 10^8$ kms., with a parallax of ·045 seconds. This prediction was brilliantly confirmed in 1921, when Pease and Anderson, at the Mount Wilson Solar Observatory, successfully devised a method for measuring the diameter of stars and found that α-Orionis had a diameter closely agreeing with the value predicted by Eddington and Russell.

For a time it was thought that this picture described correctly the actual life-history of a star, but facts began to come to light since 1922 which showed, to say the least, that the theory was untenable. We have to refer to the discovery of an entirely new species of stars, viz. the white dwarfs which are found to possess an enormous density of 50,000, i.e. 2,000 times the highest density of matter found on earth. Though up to this time only a few of such extraordinary bodies have been found, yet they are not supposed to be mere freaks of nature, for such bodies would mostly escape detection owing to their extremely small surface and small luminosity. Recently it has been suggested on good grounds that the cores of stars may be mostly white dwarfs and Milne has even suggested that all stars have a core of white dwarf type. The white dwarfs are a problem for the contraction theory of evolution, for according to this theory the limiting density cannot exceed 5 or 6, like our Earth. But the fact that the highly ionised matter inside a star can exceed the limiting value thousand times shows that the theory needs radical revision. It is impossible that such bodies can be due to any difference in composition, for they are undoubtedly binary: amongst many binary pairs which are undoubtedly formed out of the fission of one and the same body one is found to be an ordinary star while the other is a white dwarf. The best example is afforded by the Sirius pair. Sirius A having a mass of about 3 is an ordinary A-class star with the mean density of 0·93, while

Sirius B having the mass of ·85, is a white dwarf having the density of 50,000. How two stars, composed of the same material, and starting their career at the same epoch could have developed along such different lines is a problem which still requires elucidation. In addition to white dwarfs, recent explorations have been bringing to light other bodies with characteristic properties which cannot be fitted into the above scheme of evolution. Such are the supergiants, the peculiar distribution of stars in the globular clusters, the Cepheid variables, and a mass of other details too vast to be discussed here.

SOURCES OF STELLAR ENERGY.

It has now been recognized that a mathematician working with theories of stellar evolution is almost as much handicapped in his work as those who are unlucky enough to be called to the profession of weather-prophets. The problem is too difficult for a deductive treatment, as there are too many factors and it becomes difficult to trace the succession of cause and effect. As I mentioned above, we have to deal with the problem of flow of radiation through a highly ionised gaseous mass and the problem cannot be properly handled unless we know how energy is generated inside the mass (source of stellar energy), what resistance the gases offer to the flow of radiation (opacity problem), and what is the relation between pressure, temperature and density (equation of state) and further the composition of the stellar mass. On all these points, our present knowledge of atomic physics fails to give any guidance as the conditions cannot be reproduced in the laboratory. The question of the source of stellar energy has been a baffling problem to the astrophysicist. The point may be illustrated with reference to the sun which is radiating $1{\cdot}2 \times 10^{41}$ ergs of energy per year, i.e. about $6{\cdot}1 \times 10^{7}$ ergs per gm. of its mass per year. Supposing the present age of the sun to be 10^{13} years which is known to be a good estimate from other grounds, 1 gm. of solar mass must be radiating $6{\cdot}1 \times 10^{20}$ ergs, i.e. $1{\cdot}5 \times 10^{13}$ cal. of energy during its life course. Where could it have drawn upon such an enormous stock of energy ? Detailed treatment has shown that all the stocks of energy known to us are utterly inefficient. Let us take some of these : chemical, radioactive and gravitational. If we burn 2 gms. of H_2 with 16 gms. of O_2 we get 58×10^{3} calories of heat, i.e. altogether $3{\cdot}2 \times 10^{3}$ calories per gm. This is 10^{-10} times the amount needed and no chemical reaction will give an amount of energy substantially larger than the above. The next alternative is radioactivity ; if the sun were entirely made of Ur, 1 gm. of it, on passing through all changes, would emit only 5×10^{9} calories ; if the sun were made of radium, the amount would be sufficient but the sun would run out its life in 2,000 years. The energy of gravitational contraction, once invoked by Helmholtz which postulates that the star gets heated as it contracts has been also found to be utterly inadequate.

A fresh, and apparently inexhaustible, source of energy has been opened out, since Einstein proved, from the theory of relativity, that mass and energy are equivalent being given by $E=mc^2$, so that if one gm. of matter is fully converted to radiation, we would get 9×10^{20} ergs or $2\cdot10^{13}$ cals. Applied to stars this would mean that the stars subsist by *burning their masses* into radiation so that in process of time a star radiates most of its mass. There is some evidence that a star, as it gets old, loses mass, so that the hypothesis appears to rest on a substratum of truth but one would like to know the detailed steps by which mass is being converted to radiation inside a star. On this point, the rate of evolution of energy by stars possessing different physical characteristics will be helpful, as the example of the Sun is not typical but many stars are found to evolve a far larger amount of energy per gm. than the Sun.

Star	Spectral Type	Mass	Density	Radius	Temperature	Erg./gm. sec.
Betelgeuse (α-Orionis)	M_0	40	$2\cdot10^{-5}$	290	3000°	300
Arcturus	K_0					
Capella A	G_0	4·2	$4\cdot10^{-3}$	11	5650°	48
Capella B	F_0	3·3	$2\cdot8\cdot10^{-2}$	5·5	7400°	41
H.D. 1337 A	O_8	36·3	$4\cdot10^{-3}$	23·8	28000	15000
V. Puppis	B_1	19·2	$6\cdot10^{-2}$	7·6	22000	1100
Sirius A	A_0	2·45	$9\cdot3\cdot10^{-1}$	1·58	11200	29
Procyon A	F_5	1·13	$2\cdot8\cdot10^{-1}$	1·80	7000	10
Sun	G_0	1·00	1·42	1·00	6000	1·90
o_2 Eridani A	G_5	·90	3·7	·70	5600	·80
α-Centauri B	K_5	·97	$7\cdot6\cdot10^{-1}$	1·22	4400	·90
Kruger 60 A	M_3	·25	9·6	·33	3200	·068
B	M	·20	60·0	·17	,,	·021
Sirius B	A_7	·85	5×10^4	·03	8000	·007
o_2 Eridani B	A_0	·40	$9\cdot8\times10^4$	·018	11200	·002

The table shows that the rate of evolution of energy is very different in different varieties of stars. It varies from 1×10^4 ergs to one-thousandth of an erg for white dwarfs, and is almost nil for the planetary bodies. What may be the cause of such wide divergence? Surmise has been made that either the stars may essentially differ in chemical composition, or the rate of conversion of matter to energy is being largely influenced by physical conditions in the inside of stars in a way of which as yet we are completely ignorant. The treatments are highly speculative for as H. N. Russell says, 'we here lose the valuable guidance of atomic physics'. So far two distinct processes have been suggested: in one hypothesis it is supposed that originally stars mostly consisted of hydrogen, i.e. of protons and electrons. In course of time the protons inside the star combine to form more complex nuclei, and the amount of energy which is set free is available as radiation. This process may be called by the familiar term : *Transmutation of Elements* ; in the second hypothesis it is suggested that when a proton and electron collide with each other, they disappear leaving a quantum of radiation in their place. This process is known as '*Annihilation of matter*'. It was claimed, by the protagonists of both of these views, that radiations arising from these processes which take place in the inside of star though very hard (supergamma rays) gets degraded as it makes its way out and gradually gets converted into visible radiation. In support, they held that even in interstellar space, conversion of matter to energy takes place and the radiations arising in this way may be wandering in space, for they would altogether escape absorption, or any other form of degradation owing to their extreme hardness. And they identified them with Cosmic Radiation.

COSMIC RADIATION.

Subsequent investigations however showed that the identification was too premature for the only way for investigating the cosmic rays was by observation of their absorption coefficients. From this, the wavelength was extrapolated by utilizing the empirical formula between absorption coefficient and wavelength as obtained in the laboratory. But the rays produced in the laboratory are too soft, and subsequent investigations showed that the extrapolation was unjustified. The question of wavelength of cosmic rays may be said to be still hanging in the balance. We are looking forward to the day when the cosmic radiation curves will be properly analyzed, and the energy-content and the intensity of the constituents will be satisfactorily determined. But at present, there is not a shred of evidence in favour of the view put forward very enthusiastically by some distinguished investigators that a number of protons and other positive particles are conspiring in the depths of space to form heavier nuclei, and releasing the radiation which we may call cosmic.

Another fatal objection against this hypothesis is that on this view, cosmic rays would be strongly directional, i.e. coming most copiously from regions of the sky where there is some concentration of matter, the Milky Way or the globular clusters. But this has been disproved. Cosmic rays are diffuse, and the variation which has been found by Clay and Compton are more to be ascribed to the deflecting action of the earth's magnetic field on the secondary electrons and positrons formed by the electrofission of the cosmic rays as they enter our atmosphere. I do not wish to disparage the investigations on cosmic radiation.

In fact, I shall show that no astrophysicist can afford to neglect cosmic rays in any scheme of evolution.

III. NEW LIGHT FROM NUCLEAR PHYSICS.

The aid of atomic physics, so eagerly expected by H. N. Russell, has been however forthcoming for sometime past. It is however not so complete as to justify one in the attempt to construct a system, but even from the preliminary results it is clear that the riddle of the problems of stellar structure is locked up in the physics of the nucleus of the atom, just as that of the stellar atmospheres was locked up in the physics of the extranuclear electrons. For the discovery of white dwarfs and Milne's hypothesis that the cores of all stars are in the white dwarf stage renders the hypothesis extremely probable that the stars are mostly composed of light elements which, under the temperature in the inside of stars, are stripped completely of their outer shell of electrons. The stellar core therefore mostly consists of free nuclei in close packing, with free electrons slipping in the interspaces. So most of the reactions in the interior of stars would be nuclear.

The physics of the nucleus is a subject of only recent growth. For a long time the physicist's attention was confined to extranuclear electrons, and he was content to regard the nucleus as a point charge of positive electricity which, for some mysterious reason, possessed the whole mass ascribed to the atom. The investigations on the nucleus are barely ten years old, and though much still remains to be learnt, a review of the recent progress, and a discussion of the bearing of the new results on astrophysical problems is expected to stimulate interest and activity. Even two years ago, it was confidently supposed that the ultimate constituents of matter were the proton and the electron. Their charges were equal and opposite, but there was striking dissimilarity in their masses, the proton containing practically the whole mass ascribed to the atom being about 1,850 times heavier than the electron. This dissimilarity in masses has never been satisfactorily explained, but the physicist bowed to the incontrovertible fact with stoic unconcern and proceeded to weave his theories on what appeared to be a basic fact. But the situation has entirely changed owing to fundamental discoveries made last year, viz. (i) that of the *Neutron* . . . . by Chadwick in the Cavendish Laboratory, England. This is a neutral body having almost the whole mass of the H-atom, but possessing no charge ; (ii) by the discovery of the *Positron* which is the exact positive analogue of the electron. It was first recognized by C. D. Anderson at Pasadena in the Wilson photographs of Cosmic Rays Positron Tracks. In view of these discoveries, the claim of the proton to be regarded as a fundamental particle has come to be seriously questioned. There are at present two schools of opinion: one school, including my young friend Dr. Kothari, is of opinion that the proton is a compound of the neutron and the positron. The other school which includes Chadwick himself is of the opinion that it is a dipole composed of the proton and the electron. So far no decisive evidence in favour of the one or the other view has been obtained, but I am on the whole inclined to support the view put forward by Kothari and others and I believe that this view has far-reaching astrophysical consequences. For, according to many astrophysicists, hydrogen is found in abundance in the atmospheres of all classes of stars. Either the abundance continues as far as the interior or hydrogen is being constantly formed out of protons and electrons reaching the stellar exterior from the core. In any case, there is likely to be an abundance of protons inside stars. The proton, if it is a compound, will be further broken up into the *neutron* and the *positron*, for the binding energy is small, between 10^4 to 10^5 evs. and even the smallest temperature ascribed to stellar interiors is sufficient for complete breaking of the proton. The other view does not allow this breaking, for the proton being fundamental, cannot be further divided. So on the first view the atomic core will consist of neutrons, positrons and electrons; while on the second view it will consist of protons and electrons. This is fraught with far-reaching consequences. For neutrons have been found to possess the remarkable property of passing through matter till stopped by the nucleus, and when they strike the nucleus, they excite radical changes in it, resulting in the emission of protons, α-particles and γ-rays?

ELECTROFISSION OF QUANTUM.

The recent investigations on cosmic rays have also brought further definiteness to the idea of so-called annihilation of matter into radiation which, in addition to its bearing on the structure of stellar cores, may produce far-reaching repercussions on the much debated problem of '*Fate of Radiation*'. What becomes of the tremendous flood of radiation which stars are pouring out and have for ages poured out into space without interruption? This question has been a matter of as much concern to astrophysicists as the question of exhaustion of petrol supply to the power-grabbing politicians of different countries. It is well known that very little of this tremendous flood of energy can be stopped by matter in space. In a few millions of years, the radiation must have passed beyond the most distant Nebulæ. On the hypothesis of an infinite Universe, it was believed that all this radiation ultimately gets lost into the great unknown, so that as ages pass by the world will undergo a *Wärmetod*: death due to complete exhaustion of energy supply. If we accept Einstein's theory of a closed world, radiation cannot get lost into space, it will turn back, and go on cruising round the universe, making a complete revolution once in some thousand million years. But even with this picture, we are not past the danger zone. We are still faced with the crisis that ultimately the world may separate into dead matter and free radiation, or according to some protagonists of the theory of expanding universe, who do not always agree, the radiation may be spent in the work of expansion of the universe and converted into the kinetic energy of extra-galactic nebulæ. Even this view at the present time cannot be considered as other than speculative for the sponsors of the Expanding Universe theory demand a time scale which is too rapid for the stolid race of physicists to swallow. Further, it appears to me that the authors of these theories have ignored two further possibilities: firstly, the possibility of radiation getting reconverted into matter; secondly . . . . the possibility of small energy quanta combining to form high energy or cosmic ray quanta.

Speaking of the first alternative, which is the inverse of annihilation of matter, Jeans wrote in 1931 : 'Many, giving rein to their fancy, have speculated that this low level heat energy may in due course reform itself into new electrons and protons. As the existing universe dissolves away into radiation, their imagination sees new heavens and a new earth coming into being out of the ashes of the old. But science can give no support to such fancies. Perhaps it is as well ; it is hard to see what advantage could accrue from an eternal reiteration of the same theme, or even from endless variations of it.'

But Sir James Jeans who seemingly prefers Nirvana to cycles of birth for the stellar system must change his views now since the conversion of radiation into electricity is no longer a matter of speculation, but has been actually observed in the laboratory. Anderson and Neddermeyer in America, Blackett and Ochiallini at Cambridge, and Curie and Joliot in Paris have proved that γ-ray quanta of sufficient energy are converted into pairs of positron and electron inside the nucleus. We have termed this phenomenon as *Electrofission of Quantum* which means that under the influence of the intense nuclear fields a quantum of sufficient energy undergoes a *fission* into equal amounts of positive and negative electricity and gives rise to a pair of electrons and positrons. Dr. Kothari, Mr. R. Rai and myself have shown that this phenomenon of electrofission of quantum accounts, in a very convincing way, for the β-ray-activity of radioactive bodies and thus saves the physicist from a very perplexing dilemma in nuclear physics to which attention was first drawn by Bohr in his Faraday lecture of 1932 : the problem of accounting for the spontaneous emission of electrons from the nucleus which ordinarily contains no electrons free or bound. Bohr suggested that the phenomenon probably requires abandonment of the law of conservation of energy, and suggested an alternative which was virtually equivalent to creation of energy out of nothing, but before such a time honoured principle is abandoned, other avenues should be explored. It has been shown, at least to our entire satisfaction, that the phenomenon of electrofission saves us from having recourse to such a revolutionary change. The phenomenon of electrofission is the first experimental demonstration of conversion of energy into electricity, but it should be pointed out that it has brought us no nearer to the problem of wholesale conversion of mass into energy demanded by astrophysicists who want a very long time scale for cosmic events. For according to these timegrabbers, there should be a possibility of the whole mass burning into radiation. But as far as our present knowledge goes the main mass is locked up in the neutron and we do not yet know whether or how it can be changed into radiation. In this connection, some speculations of Dr. Kothari may be noted ; he thinks that the neutron is a magnetic dipole consisting of two Dirac free magnetic poles of opposite signs. The force of attraction between these two poles is so great that it cannot be ruptured even by the intense field of the nucleus, so that it is thought that in the inside of stars, the neutron is largely in a free state, and able to perform the reactions alluded to above. It can undergo a fission only when subjected to the intense field of a cosmic ray. What happens after that can at the present stage be only a matter of speculation.

The second point is still more speculative but it may throw some light on the question of origin of cosmic rays which is still open. On this point, I wish to dwell a little in detail; for, apart from the peculiar pleasure which cosmic rays have afforded to the physicists of grappling with an elusive unknown, it is not often realized that the cosmic rays may be of far greater cosmological interest than has hitherto been thought. It has now been almost surely established that they are electromagnetic in nature, being in fact hard gamma rays. Further, they seem to be quite diffuse, i.e. originating in no particular part of the sky, like the Milky Way or any nebulæ. Thirdly, their intensity in space, sufficiently distant from any nebula, is about hundred times larger than that of visible radiation, being in fact 10^{-3} ergs/cm.^{3} the equivalent mass-density in interstellar space being 10^{-33} which is only hundred times smaller than the mass-density ascribed by Hubble to free space.

Regarding the origin of cosmic rays, a probability of great importance seems to have escaped the notice of previous investigators. As I pointed out earlier, the astronomer has to work under severe limitations on account of the mantle of atmosphere which lies about the earth. On the cosmic ray side, rays softer than those having the energy 2·6 mevs are cut off even when observations are taken at the height of 22 kms. which is the highest reached by Kohlhörster, Piccard and

Millikan. It is not impossible that in addition to the radiation we observe, space is filled with softer radiation up to 3,000 A, i.e. an interval of 44 octaves in considerable amount which fails to reach us on account of atmospheric absorption. I personally have found no reason why the cosmic radiation should suddenly stop at any particular value. Whether the rays postulated by me really exist can be proved or disproved by further cosmic ray ascents into heights of 40 to 50 kms. To me it seems that there is a strong probability that such rays do exist, for it has been found with each ascent into higher heights of the atmosphere that the ionisation considerably increased and Kohlhörster finds evidence of softer radiations coming into play. If such radiations do exist, I think that our estimate of the space density of radiation has to be completely revised. It may amount to even a hundred times of the value accepted now. There is some evidence that the assumption of such radiation can explain the occurrence of bright emission lines in the spectra of many stars with extended atmospheres about them or of the occurrence of high excitation lines in the atmospheres of systems known as planetary nebulæ for whose explanation, the ionisation theory has to be twisted beyond what seems to me its legitimate limits of applicability.

For the present we suppose that such radiations do exist. The question is how they and the harder cosmic rays are formed : I have already alluded to the fact that on the view that the universe is closed, the quanta of radiation emitted from distant ages must have been wandering in space. We may suppose that in course of time two quanta may be frequently coming together, and, by a Compton collision, may produce a quantum of higher energy. It is true that experiments to observe the fusion of quanta have so far yielded negative results, and they are said to be precluded from approaching each other by Bose-Statistics,[1] but some of such collisions may take place inside matter and then the fusion we have failed to achieve in the laboratory may be brought about by what we may call in the absence of a better term by the catalytic action of matter. The quanta wandering in space may in this way go on fusing with each other till it becomes a cosmic ray quanta. This on encountering matter may undergo an electrofission, and be reconverted into the electron and the positron. Thus the hypothesis of fusion of quantum which I must admit is yet without a shred of experimental proof provides us with the missing link for rendering the whole cycle of cosmic processes reversible and cyclic. We thus get the vision of a complete picture of conversion of matter into energy-quanta and of energy-quanta back into radiation. Probably the picture will be completed when experimenters succeed in causing a fission in the neutron, and isolating the free magnetic poles first conceived by Dirac.

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[1] This seems to be due to misunderstanding on the part of these experimenters (Jauncey and Hughes, *Phys. Rev.*, 36, 773) regarding the significance of Bose-Statistics which assert, contrary to what the authors say, that quanta have got a gregarious habit of accumulating in the same point of phase space. The failure of the experiment is probably due to some deeper-lying reason, and two quanta on account of their rapid motion may not have been crossing the same point of space at the same instant of time.

IS THERE ANY EVOLUTION ?

Probably my audience would like to get a straight answer to the question : Is there any evolution ? On such a point, one is largely guided by his own sense of æsthetics, as Sir Arthur Eddington blandly puts it. You have probably realized from my hasty snapshots that at the present time owing to improvements in the technique of exploration, and to the employment of a large number of workers, a large mass of floating information has been gathered. As de Sitter says, we have Tycho Brahes, Copernicus, Galileos and Keplers of the new Cosmogony—but we still want a Newton to arrange the information into a system. Any view regarding Evolution at the present stage is bound to be highly speculative.

According to the protagonists of the expanding universe, the world is closed, and if there be any other universe besides ours, we have not discovered any method for knowing it. The main ideas of this view have gained such wide currency, owing to the good services of the modern world news agency, that it is unnecessary to dwell at length on the subject, particularly as my colleague Prof. A. C. Banerji will deal with it in sufficient detail. The best that can be said of this theory is that it is highly speculative, and cannot be accepted unless we succeed in finding out some other solid peg besides the recession of extra-galactic nebulæ (which may yet admit of some other interpretation) on which the conclusions can be shown to rest. Eddington describes himself as a detective in search of such a peg on which the cosmological constant may be hung, and he believes he has found one in a supposed connection between the electron radius, the radius of the universe, and the number of particles in the universe. It is debatable if these values have been properly chosen, and it is at best a long distance hit like long range weather prediction. I feel no hesitation in putting forth an alternative theory which is however based largely on the instincts of a physicist and may be taken for what it is worth. To illustrate my view, I shall again take shelter under the analogy of tropical forest quoted above ; suppose a set of intelligent observers allowed one hour's walk inside the forest at intervals of ten years. Will the reports of the observers differ greatly regarding the general appearance of the forest. It is expected that if the forest were a self-contained system there will be the same proportion of young saplings, full-grown trees, giant patriarchs, and mouldering trunks decaying to earth. Individual trees may be born or grow, or decay, but there will not be much of a change in the general appearance of the forest. I would submit that in Cosmos as well, Evolution may be confined to individual systems in their own way like the Earth, or the Solar System, or the Globular Clusters but when old concentrations of mass become dead new concentrations may take their place in a cyclic way. The luminous bodies are incessantly pouring out radiations into space at the expense of their mass, but probably the quanta gather up into Cosmic Rays which again break up into matter, which may gather up in the depths of space, condense and again form into stellar system. The cosmic process is thus cyclic. Matter, acting on quanta and causing electrofission, acts like a Maxwell demon which reverses the inexorable march of Entropy, a doom which has been dreaded by all Evolutionists. But the whole secret of this chain of processes seems to be locked up in the physics of the atomic nucleus to which we must look up in the next few years for clearing up the riddles which confront us in our efforts to know the mysterious Universe about us.

IV.

You may now justly complain that I have soared to such æthereal heights that matters concerning life have been completely ignored. To an astrophysicist, life is a trivial, though a perplexing episode, merely disease of matter as one astrophysicist humorously puts it . . . . which can flourish only within severe limitations of physical conditions. Living creatures, particularly men, may be compared to colonies of ants clinging for dear life to tiny fragments of a wrecked ship in a tumultuous sea and men have somehow been persuaded to the belief that they can hold out only by practising cannibalism on a large scale. To a scientist life is a queer thing, not subject to reason or law like inanimate objects but swayed in its action by inexplicable impulses which Schopenhauer collectively calls ' Will '. So far not much progress has been achieved in the understanding of the problems of life from the physical viewpoint. But for the mere reason that life is dear to us all, we cannot but be interested in its problems, but being for long unable to make any headway from the scientific side, we are not infrequently tempted, as Bishop Barnes puts it, to escape from the blind forces of Nature to the friendly care of a hypothetical and elusive Providence. The idea of helplessness, which was more keenly felt by men before the era of Science, is probably the origin of religion, but it is doubtful whether the older religions which were based upon an insufficient acquaintance of the Universe, of Nature, as well as of Organic Life, and are largely subjective in origin, have ever served the purpose claimed by their protagonists. In this connection one would like to know whether on any of the myriads of heavenly bodies I have described, there may be intelligent beings and whether they have been able to evolve a system of controlling life better than ours. There is no reason to think life should be confined to our planet alone, but it must be admitted that nobody has yet succeeded in establishing communication with such extra-terrestrial beings, though the French Academy has been proclaiming a prize of one hundred thousand francs for several decades for finding out a practical method of opening communication with Mars, our nearest neighbour. On this point, the following opinion of Bishop Barnes is well worth quoting:

'As I have already indicated, I have no doubt that there are many other inhabited worlds, and that on some of them beings exist who are immeasurably beyond our mental level. We should be rash to deny that they can use radiation so penetrating as to convey messages to the earth. Probably such messages now come. When they are first made intelligible a new era in the history of humanity will begin. At the beginning of the era the opposition between those who welcome the new knowledge and those who deem it dangerously subversive will doubtless lead to a world war. But the survivors, when they extricate themselves from the economic consequences of the peace treaty, will begin what we may correctly term a strenuous correspondence course. I should like to be living then. We might get a true understanding of the evolution of the universe.' (*Nature*, 1931.)

The present-day world requires a Prince Henry the Navigator who can conceive, organize, and finance an enterprise for large-scale experiment on these lines. Money spent on such experiments would be better spent than money spent on armaments and though we cannot much blame a politician in his actions, for he has to face problems of the immediate, it will be statesmanlike on their part if they can have the courage to organize and finance experiments which will lead to the realization of the above dream.

We believe that for long years yet to come, men on this planet will be left very much to their own unaided resources, and the best way to ensure the future is to foster the scientific spirit, by education as well as by propaganda, and to encourage scientific enquiry into not only purely scientific subjects like physics or biology, but also into Social Sciences. For, up to the present time, the forces which have been used for controlling human passions are religious, political and social laws. As I have very often remarked, these laws have been arrived at from an imperfect understanding of the problems of life, of world problems, and from the exigencies of situations of an ephemeral nature. In this connection, it may be worth while to quote from the speech of an experienced and sympathetic ruler of men, His Excellency Sir William Malcolm Hailey, Governor of U.P., on the occasion of Inauguration of the U.P. Academy of Sciences in 1931:

'I suppose that we would all agree, that what we look for in the future is the assistance of science,—if it can give it—in securing a more rational manipulation of human nature. Can it, for instance, give man a domination over his own passions equal to that which it seems to be achieving over the physical forces of the external world? We used to think of the domination of passion as an ethical problem for the individual; but it is the unhappy tendency of modern times to translate individual into mass action, and collections of people now seem to find excuse for passional absurdities in the mass which we should certainly recognize as harmful in the individual. It is perhaps a common-place, but it is nevertheless true, that a generation which ridicules its predecessors for their scientific ignorance, has shown emotional irrationalism on a larger scale than the world has ever seen before. I do not refer merely to the fact that it made a world war; perhaps that was only a temporary ebullition of world passion; but its subsequent performances in tariff wars, in dealing with its principal medium of exchange, or with the problem of disarmament, certainly do not seem to show that it has grown in mental balance. Can science again do anything to rectify the psychology of fear which now seems to dominate the world—fear of national ruin, and fear of material insecurity both to the individual and to collections of people? A sense of insecurity, or a sense of thwarted life, physical or material, is a real source alike of mischief and unhappiness. Can science again do anything to aid the moralist in removing some of the malevolence which does actually seem to form a part of common human nature and which continues to thwart the progress made by the growth of the social sense? It is possibly physiological in origin, which may make scientific attack in the end more efficacious than purely moral suasion. Our conclusion must I suppose be that science is really only one of the agencies which are available for removing these somewhat basic disturbances in the human balance.'

The way in which Science can be of help in aiding the statesmen of the world in solving the problems above referred to is contained in my speech delivered on the same occasion:

'Though there are many evil things on which all shades of opinion are agreed, most of the human tragedies, national, social or civic are, as Hegel aptly remarked, due to conflict between Right and Right, i.e. what is right to one group, has appeared just the opposite to the other group. Is it not possible to find out an absolute standard of the Right, independent of time, locality or tradition? Most of the present views of the Right are derived from the so-called Scriptures, law books and social codes; they still govern the majority of mankind though they date from distant antiquity; but if we discard the pretension of divine origin which is claimed for them by Pundits of the orthodox class, it should be admitted that they were based upon insufficient knowledge and analysis of Nature, of life, and of the actions of the human mind. Is it not possible to subject these last to a searching scientific analysis, and find out absolute standards? Spinoza thought that this was quite feasible.

'Not to laugh or weep over the actions of men but simply to understand them, and to contemplate their affections and passions, such as love, hate, anger, arrogance, pity and all other disturbances of the soul, not as vices of human nature, but as properties belonging to it in the same way as heat, cold, storm and thunder belonging to the atmosphere. For these, though troublesome, are yet necessary, and have certain causes through which we may come to understand them, and thus by contemplating them in their truth, gain for our minds as much pleasure as by the knowledge of things that are pleasing to the sense.'

Scientific methods have been applied by scholars to the study of subjects of more human interest like Civics, Politics, Economics, History, Social Eugenics, and Experimental Psychology, and it is generally the custom to designate them under the collective name of 'Anthropological or Social Sciences'. They deal with the 'Human Mind', and therefore form a natural sequel to the study of the physical sciences which deal with Nature, and biological sciences which deal with individual life. These sciences deal with collected human-life and invade the forbidden grounds of religion, social codes and politics, and some of their findings alarm the vested interests to the same extent as Copernicus's heliocentric theory of the solar system frightened the churchmen of the fifteenth century. But for the good of the world, it is not only desirable that they should be pursued with greater vigour, but their lessons should be applied with great determination to all forms of human activity.

In fact it has appeared to many thinking men that much of the evils of the present-day world are due to the non-adaptation of the human organizations to the changing conditions of the world. Owing to improved methods of communication and to much better contact between different parts of the world, the world is fast becoming one economic and cultural unit. But the politicians still persist in their Olympian attitudes.

Before the great World War, the politician was at the stage where the Physicist found himself before the time of Archimedes, or better in the days of Homer and Hesiod. His country was his Olympus, his own people were his gods, all others were demons, barbarians fit only to be secured against the stroke of the sword, or exploited as helots. The Great War, and all other wars before it were the result of such a mentality, but the Great War exceeded all previous wars in the intensity of destruction and havoc because science placed more power in the hands of men. But it did one great thing, it exposed the absurdity of international quarrels. When the late M. Clemenceau visited Egypt, and was taken round the Pyramids, he commented rather sarcastically on the vanity of the Egyptian Pharaohs who built huge stone monuments with slave labour for the sake of housing their Ka (Soul). He was reminded by a Cairo paper that if the Soul of Cheops, the Pyramid building Pharaoh, could be released from his stony sepulchre, he could have retorted that the Treaty of Versailles and the expenditure on Dreadnoughts, and on military armaments and sacrificing the finest youths of the country before the bloody altar of Nationalism, were far greater absurdities ; as one-tenth of the money wasted in the war, if spent on internal development of the natural resources, would have given every belligerent country a far greater amount of security and prosperity than the politicians ever dream to achieve by methods peculiar to them.

THE PRESENT WORLD—ONE ECONOMIC AND CULTURAL UNIT.

At present, the fact is only slowly dawning on the public that the world is fast becoming one great economic unit. A crash in Wall Street leads to a strike in the Bombay Mills, and unemployment in Lancashire leads to fall in the price of jute in Bengal, and ultimately to Hindu-Muslim riots. A prosperous year in India leads to an increased consumption of foreign goods. Overpopulation in Japan and China causes a clash in Manchuria between the two peoples, and is fraught with menace towards Australia and insular India and to world peace. The rulers of countries cannot therefore persist in their Olympian attitude towards other nations—they must become earth-wide in their outlook. But this is prevented by the present faulty system of education which seeks to perpetuate the mediæval mind, and brings only a small percentage of the population under the humanizing influence of science. The result is disastrous ; those who are called upon to guide the nations are mostly men with a rigid outlook, quite unfit to fathom the depths of present-day troubles, or analyze the intricacies of political and economic issues, and unable to hold out any programme of reconstruction. In our country, the result is competitive communalism ; among the free nations—a tense atmosphere of competitive nationalism, and between the ruler and subject nations—a spirit of revolt against suffocating imperialism.

But economic and scientific studies show that the world has resources enough for her whole population, and if there be a rational programme of production, and a programme of judicious and equitable distribution, nobody should suffer from hunger, privation, and can even afford to have much better amenities of life. But for this purpose, rivalry amongst nations and communities should give way to co-operative construction, and the politicians should hand over many of his functions to an international board of trained scientific industrialists, economists, and eugenists, who will think in terms of the whole world as a unit, and devise means by which more necessities of life can be got out of the earth; the whole production should be controlled by scientific industrialists, and the distribution should be supervised by the economists. The eugenists should devise means for assigning a fixed quota of population to each geographical unit, which it should not be allowed to exceed. It may seem to be a dream, but is perfectly feasible provided the educational programme is thoroughly revised. A new educational scheme should be devised by a World's Congress of foremost thinkers like Bergson, Einstein, Bertrand Russell, Smuts, Spengler, and others, with the special objective of weeding out mediæval passions from the minds of the coming generation, and for training them to a proper grasp and sufficient appreciation of the beauty and powers of science. The joy of life for the grown-up men will be provided not in designing means for the plunder or exploitation of our fellow-men in various ways but in administering to their needs, and in free development and display of the finer faculties of the mind.

APPENDIX I.

THE PROPOSALS FOR AN INDIAN ACADEMY OF SCIENCE.

At the present time, the hopes of World-Peace based on a scientific handling of economic and political problems appear to be, as you are well aware, very distant, for the world forces are moving in such a direction that it is more likely that instead of establishing an era of world-peace, and co-ordinated scientific exploration for the benefit of the whole mankind, the present generation will fulfil Spengler's pessimistic prophecy of the end of a cycle resulting in the crash of modern civilization. In any case whether we move towards peace or war, it is clear that the prospects of a better future lie entirely with science. Every country must, for the sake of self-preservation, as well as for the benefit of mankind husband all its resources scientifically and must foster and stimulate scientific. thought. The great industrial ventures, whether private or State, must make increasing use of science, for otherwise they will not answer the world needs and achieve the desired results.

So in every country, India not excepted, the State must awaken to the need for a proper organization of her scientific brains. Confining to our country, it is well known that a good amount of scientific work, which often led to great industrial enterprises, has been done in the past by the various scientific Services. Within the last few years, the Agricultural Research Council has been founded in which a happy departure is noticeable. Unlike the older services, whose organization probably did not enable them to make use of non-official scientific brain available in the Universities or private institutions, the constitution of the Agricultural Council has been such as to enable it to make full use of all available talent—which is a happy and new departure in the policy of the Government of India.

In this connection, the non-official scientific men have a just cause of grievance against the Government. I remember to have read, a few years ago, a short article by our energetic secretary Dr. Agharkar, in the *Modern Review* where he invited attention to the close co-operation existing between workers in the scientific services of the Government, and Professors in Universities in other countries, and complained of its total absence in this country. In other countries, the co-operation is so complete that it is not unusual to find that Universities and Services very often exchange their workers to the mutual advantage of both. I do not see why this co-operation should not be secured in our country as well, and the existing services should not be reorganized on the lines of the Agricultural Research Council.

NEED FOR A RIVER PHYSICS LABORATORY.

There are many lines in which the Government of India as well as the Provincial Governments can profit immensely if they take the trouble of obtaining proper scientific guidance before launching on large-scale enterprises. As many such cases are not known to you all, I would refer to only one. You are aware that year after year, the Government and other public bodies spend an enormous amount in constructing bridges and water reservoirs, in opening canals, in development schemes, in hydro-electric schemes, and in city drainage schemes. These schemes are certainly highly beneficial and undertaken with the best of intentions, but you are certainly also aware that from time to time, very unpleasant facts leak through the columns of the news agency, which show that these schemes are mishandled at some stage or other. Every scientific man knows that before the actual working commences the plans should be scientifically studied in Hydraulic Research Laboratories, with the aid of models and the engineers in charge of constructions should have a clear-cut idea of the work before they are put in charge of it. You may be knowing that in spite of the fact that next to the United States of America, India is the country which has undertaken such works on the most gigantic scale and has spent hundreds of crores of rupees on these works, the Government has not yet thought it fit to establish a single Hydraulic Research or River Physics Laboratory in this country while in other civilized countries no such enterprise is allowed to be undertaken unless the plans are examined in suitable laboratories attached either to the Universities, Technical High Schools, or state departments with the aid of suitable models. For conveying to you an idea of how such work is carried out in India, I have given in the appendix the opinion of the late Sir F. Spring, an eminent engineer who constructed a large number of railway bridges in India during the last generation, and I would request my readers to read this appendix very carefully. I should merely add that I am not against the launching of the schemes, in fact many of them, like the Panjab Canals, have done immense good to the country. But others, like the Orissa and Midnapur Canals, were constructed on faulty lines, and involved the state in huge financial losses; while other schemes like the laying of railway lines through major parts of Bengal without a proper examination of topography and of the river systems have plunged the country into perpetual outbreaks of malarial epidemics, and led to the sapping of the vitality of the population. I do not hold that either the engineers or the officials are responsible for these failures and disasters. In fact I think that most of them like Sir F. Spring tried to make the best use of a bad situation. But the fault is due to lack of imagination on the part of those who have taken upon themselves the task of Government and to their failure in devising a proper system of co-ordinated work in which preliminary scientific study in suitable laboratories should form an essential part of the organization.

NEED FOR A NATIONAL ACADEMY OF SCIENCES.

It is clear that for these and other reasons which are too numerous to be discussed here, it is necessary that scientific men in India should be better organized, and should try to impress upon the Government, the States, and other public bodies the need for encouragement of scientific research, and for a scientific handling of economic and industrial problems of the country. The best way for them to do so is to organize themselves into a corporate body, and it appears to me that the movement for establishing an Indian Academy of Sciences has started at the right moment. Our energetic secretaries have in the pamphlet now in your hands acquainted you with the full history of the movement, as well as of the various proposals for carrying the idea into action. To this I have little to add except that the United Provinces Academy of Sciences, which is now three years old, has been moving in a similar direction, and has passed the following resolutions which I have the honour of submitting to you for your opinion and action thereon:—

Resolution No. 2 of the *Academy of Sciences, U.P.*, dated August 10, 1933:

> 'That the Academy welcomes the proposals of the Council that the Academy of Sciences, U.P., should become the All-India Academy of Sciences.'

Resolution No. 2 of the *Academy of Sciences, U.P.*, dated December 19, 1933:

> 'That Dr. Saha be requested to bring to the notice of the Scientists attending the ensuing Science Congress at Bombay the resolution of the Academy of Sciences, U.P., dated the 10th of August, 1933, and to discuss the whole question with them, and to report to the Academy at its next meeting.'

On going through the various proposals, one finds, as is naturally expected, considerable divergence of opinion, regarding the manner and details of organization and it has appeared to me advisable that it will probably help the general body here to arrive at a practicable course of action, if I were to summarize these views and give my own ideas on them. You are not expected to adhere to my views, but these may be regarded as commentaries on the proposals which the secretaries have brought forward for discussion (p. 2). These are :

(i) Whether it is desirable to form an Indian Academy on lines similar to those in Europe or America.

(ii) If answer to (1) be in the affirmative, whether

  (*a*) there should be one Academy for all branches of learning,

  or

  (*b*) there should be separate Academies for Arts and Letters.

I have no reason to doubt that answer to (i) would be in the affirmative.

Regarding (ii) there are two separate issues involved:

First of all, it is clear that the Academy cannot assume the functions of the sectional societies dealing with different branches of science, consisting of scientists engaged in research in these branches like the Indian Chemical Society, or the Indian Botanical Society, or the various mathematical societies having an unlimited membership. This is neither necessary, desirable, nor feasible. It is true that many branches of science have not yet organized themselves into societies. It is hoped that they will do so in the near future, and it will be one of the duties of the Academy to help in the organization of these societies. But as long as they are not in existence, the Indian Academy may continue to take care of these subjects.

The Indian Academy will therefore be a Central Society, on which all branches of science will be represented, or to borrow a simile, it will form like the Royal Society in England, or the Prussian Academy in Germany, the apex of a pyramid of societies devoted to particular subjects. It should have therefore a limited membership. Its membership should be regarded as a mark of distinction and honour and the Academy should be associated with the State in a number of responsible duties involving scientific work.

If the Academy is started on the above lines, I think it may undertake the following works:—

(i) It will publish 'Comptes Rendus' or Proceedings like those published by the National Academy of Sciences, United States of America, which will contain only the results in long or short abstracts. It should not in general undertake the publication of a Journal devoted to a particular subject. These will be left to the societies and services. It may in addition publish memoirs and transactions.

(ii) It should take over the organization of the Indian Science Congress.

(iii) It should try to induce the State to form National Research Committees, on which the Academies should have fair representation.

(iv) It should secure and manage funds for Scientific research.

(v) It may act as a liaison body between societies for various branches of science, provincial academies, universities, services, and private organizations for scientific research.

(vi) It may undertake and promote enquiries regarding problems of national welfare.

(vii) It should represent India on International Bodies for International Co-operation.

OUR PROTOTYPE—THE ROYAL SOCIETY.

In drawing the above scheme, I have taken as our prototype the Royal Society of London whose function and organization seem best suited to our conditions. The Royal Society was founded in 1663 in response to a widespread movement initiated by Francis Bacon for the cultivation of scientific subjects. The other famous Academies of Europe like the French Academy in Paris, or the Academic dei Lincei in Rome were founded about the same time, some earlier, others later, and they were all the result of a widespread movement which may now be called romantic and which believed that the cultivation of science would usher in a new era in human civilization. The history of the past three centuries shows that the movements for scientific study of Nature have led to an enormous increase of power of the European people, which has enabled them to dominate the whole world. When these societies were started, science was one, but in process of time, it has branched out in innumerable lines, and to meet the special needs of the growing sciences societies were started at different dates out of the first mother society. We can refer to the chemical, physical, geological, Linnean (botanical), astronomical and other societies which have grown in this way in England. But this has not rendered the Royal Society useless. On the other hand, its importance has increased as the meeting ground of all schools of scientists ; and at present, the Royal Society is regarded as the apex of the pyramid of societies, and every British man of science regards it as the highest scientific honour to be elected to its Fellowships which are limited in number. It will probably interest you to know the representation of different sciences in the present body of Fellows of the Royal Society. It is as follows:

Physics and Meteorology	77
Mathematics and Astronomy	53
Engineering	24
Chemistry (all branches)	70
Medicine (all branches)	90
Zoology	36

Botany	34
Geology	35
Psychology	5
Miscellaneous	12
National Work	8
Archæology	3
	447

(ii) The next point for us to consider is whether the Indian Academy of Science should be organized as an individual unit, or should form part of a larger organization including an Academy of Letters, and possibly an Academy of Social Sciences. You may see from the pamphlet issued by our secretaries that a good deal of interest in this subject is being taken by a number of distinguished British public men including the Rt. Hon'ble the Marquis of Zetland (better known in this country as the Earl of Ronaldshay who was some time Governor of Bengal) and Prof. F. W. Thomas, the distinguished Oxford Orientalist. I would ask you to join with me in thanking these gentlemen for taking so much interest in Indian affairs. The first letter from this committee was addressed to a number of Indians distinguished in the field of letters and science, and in public life, asking their opinion on the advisability of starting an Indian Academy comprising Science, Letters, and Arts; to which replies must have been sent. We are not in possession of these opinions, but the observations of the British Committee on these opinions are before you in the form of a second letter by the Marquis of Zetland and Prof. Thomas which, with their permission, has been printed by our secretaries. It is rather regrettable that it was not possible for us to act on the suggestion contained in these letters that representatives of literary opinion should be invited to discuss the matter with us, as the programmes of all conferences which may be assigned to 'letters' are fixed a year ahead, but I have suggested to our secretaries that next year an effort may be made to hold all conferences, e.g. the Oriental, the Philosophical, the Economic and the Indian Science Congress at one central place to which also other distinguished men of letters not belonging to any specified group may be invited. If this plan materializes, the representatives of different bodies can meet and discuss the points raised by our British friends.

But the Indian Science Congress need not wait for this conference. It can forthwith proceed to the task of organizing an Indian Academy of Science. In fact there is an advantage in taking the lead now, for as you are all aware the men of letters and those representing the Social Sciences in our country are not as well-organized as scientific men, and if we succeed in evolving an organization, they may take it as their model.

I find, however, that our British friends are desirous of ascertaining whether the proposed Indian Science Academy is likely to adhere to the greater organization of an Indian Academy, containing sections on Letters and possibly also on social sciences modelled on the lines of the British Academy of Great Britain. Unfortunately I am myself ignorant of the constitution of the British Academy, but personally I see no harm in a loose federation, and it is a fact that in France and Germany, federations of the Academies of Science, Letters, and Social Sciences do exist. I would only refer to the famous Institute of Paris which is divided into sections, each retaining its individual office organization, funds, and its own rules for management and election of fellows, but joining hands on certain momentous occasions, and for sending representatives to National Councils and International Organizations. The Prussian Academy of Science has similarly sections on Philosophy and Letters, and on Physical and Biological Sciences. I would suggest that the members of the general body here with whom the final decision rests will carefully go through the letters of the Marquis of Zetland and Prof. Thomas, and arrive at some conclusion which is likely to be beneficial for the future of India. Personally I think that the offer of help so kindly promised particularly in securing for us a Royal Charter, should be thankfully accepted.

(iii) To consider the standard of attainment considered necessary for election as a member of the Academy, which will determine its size.

Regarding (iii) I think that the general body here will only fix up the maximum and assign the quota to various sciences, and other interests and leave the rest to be filled up later by a Committee which will be elected to frame the constitution, rules for election, etc. . . . . The abstract of the composition of the R.S. which I have prepared may give us some guidance. The final recommendations of the Committee which may be authorized to correspond with the Government of India, the various Provincial Governments, Societies in India and outside and with the group represented by the Marquis of Zetland and Prof. Thomas, may be placed before the next Science Congress. I would only suggest that in the case of each person who is finally selected to be a member of the Academy, a full list of qualifications and other attainments should be prepared and circulated.

(iv) The relation of the Academy to the existing learned societies. . . . .

This may be left to the committees.

(v) The location of the headquarters and the method of work.

This is the point which is likely to produce the greatest amount of divergence of opinion. It is natural that everyone should press the claims of the particular city to which he is attached for one reason or another ; but if we wish to achieve anything substantial, it is clear that we must stand above our petty interests and view the question from the higher platform of the interest of Progress of Science in this country. I would personally like that this question be not considered at the present meeting, but we may wait till the labours of the Committee are completed ; and the point may be brought before the next meeting of the Science Congress for final decision.

APPENDIX II.

Opinion of Sir F. Spring on the need for a River Physics Laboratory.

THE ABSENCE OF ANY ORGANIZATION FOR RECORDING EXPERIENCE OR RESEARCH IN CONNECTION WITH THE PHYSICS OF GREAT RIVERS.

1. 'As trustees of so fine a property as this—canals and railways—it might not unreasonably be expected that the State would see the importance of devoting a comparatively small annual appropriation to original research, on lines likely to be productive of a good return for the expenditure, in the form either of reduction in the first cost of its public works or of their safety and their economical upkeep when built. *Heretofore there has been no pretence of organizing any such research* in connection with the engineering of the canals and railways of India. *Engineers have gone on blundering, benefiting, rather by chance than by design, by the experience of their predecessors, and each considering himself lucky if he escapes disaster at the hands of the tremendous forces of nature—amongst which some of the most potent for good or evil are the great rivers—with which he has to struggle.* Until quite recently there has been practically no encouragement, and indeed at times there has been discouragement, to men to publish their experiences. And so, in spite of having perhaps as fine a body of scientific engineers as any country, not excluding France, has in its employment, and in spite of this body of public servants having carried out daring and extensive works of a certain character, chiefly, in connection with the great Indian rivers, on a scale unparalleled elsewhere, the State possesses the most meagre record of the history of the works carried out so successfully by its employees. In putting the chapters of this book (*River Training and Control* by Sir F. Spring) together, the author found extreme difficulty in ascertaining what had been done, what difficulties had been encountered, and how these difficulties had been surmounted, and it has needed the expenditure of nearly a year of research to enable him to offer to the Government of India the advice, contained in the foregoing chapters, in regard to one limited phase of the engineering of great rivers. Time will show the value of that advice, and doubtless further experience will modify the practice recommended. But meanwhile *the author would urge on the Government the importance, from a mere money point of view, of insisting on the maintenance of an intelligent record of the history of such works as those dealt with in the foregoing chapters.*'

THE CONSEQUENCES OF LACK OF ORGANIZATION.

2. 'With regard to the physics of long reaches of the great rivers, the author is not in so good a position to speak. His special experience has been gained rather on short lengths of such rivers in contiguity to his works. In view of his practical inability to regulate the flow of great lengths of such rivers he has viewed the inimical consequences of the irregularities of their flow, in the form of deep and dangerous scour, as requiring to be fought by sheer irresistible force rather than by coaxing. This necessarily must be the attitude of the engineer in charge of great bridges, and perhaps to a lesser extent of those in charge of great irrigation weirs. But *they ought not, for that reason, nor ought the State, to lose sight of the importance of endeavouring, by consistent, logical, and well-organized research, to learn something more definite than is now known about the physics of long reaches of rivers.* A perusal of Chapters III and XXI, as well as of Mr. R. A. Molloy's Technical Section paper No. 118, will suffice to show how blindly, heretofore, in the interests of the residents on their banks, men have been fighting against the ill-will of some of the great rivers; whether on behalf of the maintenance of levees[1] whereby devastating floods are excluded from great inhabited areas; or for the conservation of the hands of inundation canals on whose integrity the welfare of many thousands of people is dependent; or *in the interests of riparian cities whose obliteration would be a blot on the administration of civilized and intelligent rulers. It is difficult to avoid the conclusion, after perusal of Chapter XXI, that for lack of adequate knowledge, the engineers concerned with the interests of the inhabitants of the valley of the Indus have been obliged to work more or less in the dark in their fight with that river, and to make matters worse it has constantly happened that, owing to the climate, to the exigencies of public service, no sooner does one engineer get some small inkling of the tricks than he is replaced by one with all his experience to gain ; and in six months he, in turn, is replaced by somebody else whose experience of the river has perhaps been limited to crossing it. How, under so haphazard a system, anything gets done at all is a marvel ;* and instead of being surprised at £100,000 worth of work having been wiped out, the State may congratulate itself if the loss is not double. However, there is always the satisfaction, in the case of such expenditure as that dealt with in Chapter XXI, that the whole of the money has remained in the country, and that if the taxpayer takes money out of his coat pocket only to put it into his waistcoat pocket he can always pick it out again, or its equivalent.'

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[1] This is a word of French origin, which is used in the U.S.A. to denote embankments.

SUGGESTION FOR THE APPOINTMENT OF A RIVER COMMISSION.

3. '*The appointment, for say* 10 *years, of a River Commission not merely for the Indus, but for the organized study of the physics of great alluvial rivers generally, would be a service to civilization and an act worthy of a great State.* The Mississippi Commission have done a great deal, but their experience is not to any great extent applicable to Indian conditions. The experience of the engineers of the Rhone and the Danube and other European rivers, though valuable in its way, is even less applicable to India than that gained on the Mississippi. Mr. R. A. Molloy's attempt at a theory, as summarized very inadequately in Chapter III, is the first that can be characterized as a scientific generalization of the river problem that the author has heard of in India. And even this is based on inadequate data, picked up anyhow, amidst the multifarious duties falling to the engineer to a system of inundation canals. There is need for a thoroughly scientific location, and for the automatic reading of gauges at hundreds of places, for several years, along great lengths, selected with care and knowledge, of several of the great Indian rivers, also of some systematization of the surveys which usually are undertaken on these rivers, and of the making of fresh surveys specially designed to elucidate facts, also of an organized system of soundings and sections. The engineers in charge of the work must steadily keep in view the ultimate object of it, and must not make a survey merely for *the sake of a section. The object in view will be: To present to the scientific world, and especially to the engineering world, and more particularly to the engineers of structures in India that are subject to fury at the hands of the great alluvial rivers, such an explanation of the probable action of these rivers, under various circumstances, as will allow of such action being anticipated; and especially to enable the engineer to utilize fully his knowledge of the rivers*, so that he may make a servant of it, instead of being as it is now very often the case, his master. There can be no doubt at least from the author's point of view—*that more money has been wasted, for want of just such knowledge as a River Commission might provide, than would have sufficed to pay the entire cost of it many times over.* Certainly, so far as training works in connection with bridges are concerned, in rivers of the class with which the author has chiefly concerned himself, most engineers responsible for such works would probably admit that whether they spent money unnecessarily as an insurance against their inevitable lack of scientific data, or that they were unduly economical, with either disaster, or heavy annual recurring expenditure in after years, as the result. Thus looked on from the lowest or merely commercial standpoint, the establishment of such a Commission ought to be highly remunerative.'

Section of Agriculture.

President :—Dr. S. S. Nehru, B.Sc., M.A., Ph.D., LL.D., L. en Dr., I.C.S.

Presidential Address.

Electricity and Plant Growth.

Fellow Delegates,

It is for me a great honour and privilege to be called upon to preside at this meeting. My gratitude to you is deep, and I particularly welcome that privilege and honour not only as an over-generous recognition of my modest efforts in a new field but much more for the invaluable opportunity which was mine, when, as your President, I was fortunate enough to visit very many important centres in Western lands and survey the progress and prospects of the application of electricity to agriculture, a subject to which you would attach increasingly great importance. This very modern subject, the potentialities of which cannot even yet be foreseen, falls under two heads: the *application of electricity to plant growth* or *Electroculture* proper on the one hand and its *application to farming operations* or *Electrofarming* on the other. These are by no means water-tight compartments but represent a convenient classification. The latter, i.e. Electrofarming as such, has made spectacular progress and has been reserved for a popular illustrated lecture elsewhere. The former, i.e. Electroculture or the application of electricity to plant growth, is a much more complicated and even disputed subject and will be dealt with here.

I propose to take you through a consideration of the principal Indian Methods employed, explaining their genesis, need, and applicability, to examine some of the more important and revealing contacts made abroad relative to those methods, to present some of the more crucial questions that have been raised, and finally to project a few typical photographs, which exemplify the far-reaching response of plant growth to electricity.

The *classical* methods, from which our *Indian* Methods are a radical departure, consist in discharging electricity, for indefinitely long periods of time, from a system of thin wires spread over the area to be treated. The network is supported over insulators connected to poles with a span of 30 feet between adjacent supports which is high enough for farming operations to be carried on without interference with, or danger from, the apparatus, which is fed with a high-tension alternating supply of electricity. This will not do for India or the Indian peasant, because of (1) the great cost, (2) the technical difficulties involved, and (3) conflicting results obtained. As to (1), Borlase Matthews[1] has estimated it at £200 per acre, a prohibitive figure for India. As to (2), no Indian peasant would be able to operate such a highly complicated electrical installation for the exceptionally long periods of time such as 848 hours in a typical case. As to (3), conflicting results along with other reasons explain why the application of these classical methods is not an economic proposition, even in the west.

For the Indian farmer, the *special* apparatus designed must meet the following *ideal* requirements: capital, running and replenishing charges should be very low; it should be simple and fool-proof: and one brief treatment should evoke powerful response and give attractive results. Hence, first and foremost, the new Indian Methods should treat, not the circumambient atmosphere, as heretofore, but the *seed*, the *root*, the *soil*, or such parts of the growing plant as are called upon to respond directly and immediately. The period of treatment should be a few seconds or minutes and should suffice for a lifetime, as was actually fixed by preliminary[2] tests; and the better response should be good enough in the special cases of plant pests and plant diseases.

Methods of Seed Energetics.—The seed has latent or potential energy circumstanced by its constitution and conditioned by outside factors under the operation of which such energy will manifest itself as vigorous growth. Evidently, different seeds will behave differently: a mustard seed will germinate in 12 hours; a teak seed in months. Hence the object of seed energetics will be to secure early development of the seed within the coat, earlier germination, earlier maturity and growth, increased resistance to pest, disease, and other adverse factors, better yield and longer life. Some objects are served largely by one method; others by another. Progress has been along wholly empirical lines justified by results. These methods are as follows:

1. *Sparking Methods.*—The seed is subjected to a spark or electric discharge at a high potential, from 1,000 volts upwards, for one minute. The technique is very simple: current is taken from an accumulator, say that in the lighting set of your motor-car, and fed into the primary circuit of a small induction coil, while the secondary circuit of the coil delivers the high tension spark. This is passed through the seed individually if few, or *en masse* if many, by spreading the seed out on an insulated metal-plate, attaching one terminal to the plate and letting the other play over the seed in the former and over the plate in the

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[1] Borlase Matthews, Electrofarming, 1929.

[2] Nehru, Experiments in Electrofarming, 1931, Preliminary Tests, p. 15 et seq.

latter case. Roughly speaking, a spark of 1 cm. denotes a tension of 6,000 volts and by adjusting the spark-gap and so the spark itself the requisite tension can be fixed. Each kind of seed has characteristic behaviour. Thus, mustard *appears* dull, indifferent, and non-conducting: and yet the effect of a single treatment has been so far followed into the[1] *fourth generation*; sann hemp conducts and breaks the spark up into a thousand, beautiful sparklets, looking like diamond rain in the dusk; cauliflower seed actually gets charred and burnt, being very inflammable. But the subsequent growth of such seed, non-conducting, conducting or inflammable, has shown a powerful response to treatment. The *precautions* to be taken are: (1) the seed must be *dry*; (2) it must be *insulated*; and (3) it must be sown at once after treatment *without handling*.

2. *Radiation Methods.*—Seed is energized not by spark, but by radiation, as (1) violet rays, (2) ultra-violet rays, and (3) x-rays. For *violet rays,* the apparatus used is a simple violet ray machine, such as the Radiolux, used by doctors. Exposure and precautions are the same as for sparking methods. For *ultra-violet* rays a suitable source is the well-known Cooper Hewitt mercury vapour lamp, or still more simply a carbon are formed very cheaply by passing the town current, properly resisted, through electrodes of graphite, or even bits of a so-called lead pencil. Exposure and precautions are the same as before. And lastly for *x-rays*, the softest rays are used and the mildest dosage given, exposure and precautions being the same as before. Distance of seed from target is 20 cm. and an aluminium filter 0·5 cm. interposed to weaken still further the rays which are at an amperage of 2 milli-amps and a peak voltage of 46,000 volts.

3. *Radiomagnetic Methods.*—These methods represent a further step towards the utilization of weak stimuli, but the sum-total in both cases may be the same, whether a powerful source of energy acts for a minute only or a very much weaker source acts continuously on the plant from seed to seed. Seed is sown in a special bed called *radiomagnetic*, a portmanteau term. The bed is prepared by burying iron wire-netting at a depth of 6 inches and attaching it at one end to a radio antenna. The *magnetic* bed with the *radio* antenna forms the *radiomagnetic* bed. The effect is magnetic as it captures the earth's magnetism. Strawberry plants growing over such a bed show precisely the same response as those whose fruiting shoots are enclosed in a horseshoe magnet in consequence of which magnetic treatment those shoots ripen earlier and yield a bigger and better fruit than the fruit of untreated shoots. To rule out all possibility of outside factors playing in, this *crucial* test was made on one

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[1] Nehru, New Experiments in Electrofarming, 1933, Effect of Electro-cultural Treatment in the Fourth Generation, pp. 30–32.

and the same plant.[1] These methods have undergone considerable variations, regarding the size and location of the aerial, size, and location of the magnetic bed, size of mesh, etc.

There arises the practical question: What about the comparative efficacy of these different methods? This can be determined by practical results and not by theoretical considerations. To that end, tests have been made with a variety of seed treated by different methods, care being specially taken to keep all other factors except the treatment the same for treated and control. Thus the two sets of beds were prepared in the same soil and quite close to each other to ensure the same soil fertility, texture, composition, humidity, insolation, aeration, etc.

The results of the wide variety of tests may be considered in the following series:[2]

Series I.—The treatments and beds were respectively: I. *Violet rays*; II. *Control or no treatment*; III. *High Tension Spark*; IV. *X-rays*; V. *Radiomagnetic bed*; and VI. *Ultra-violet rays.*

The seeds treated were (1) Rice; (2) Koni; (3) White Til; (4) Soya; (5) Lobhia; (6) Madua; (7) Gahat; (8) Mung; (9) Black Til; (10) Barley 25; (11) Cotton 520; (12) Cotton 402.

Station Naini Tal, 6,700 ft., May, 1931.

These miscellaneous plants sown unseasonally and exceptionally in the Himalayan foothills show that, as regards *germination*, the *Radiomagnetic* bed reduces germination period very considerably, sometimes as much as 50%. Next in efficacy come *X-rays*, then, *High Tension Spark*, and last, *Violet-rays. Ultra-violet* rays caused exceptionally quick germination, but no comparison is made as sowings in this case were delayed due to delay in procuring the rheostat. As regards *growth*, *Radiomagnetic and X-ray sowings again lead*, increase over control being 100% in some cases. As to *yield*, *Radiomagnetic* is an easy first, then *X-rays*, and finally others.

Series II.—The treatments were: *Radiomagnetic bed without aerial* No. 1: *Radiomagnetic with* wire-netting extended and raised at one side to a height of 2 metres to form *aerial*; and *No treatment* for control.

The seeds treated were (1) Madua; (2) Koni; (3) Til; (4) Lettuce.

The tests were carried out in Naini Tal, 6,700 ft., April, 1932.

Here again the superiority of Radiomagnetic treatment was obvious. The seeds do equally well with or without aerial, barring madua which does better without aerial, the magnetic part of the treatment being essential.

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[1] Nehru, Further Experiments in Electrofarming, 1932, the Response of the Strawberry plant to Electrocultural Treatment, p. 3.

[2] Nehru, Further Experiments in Electrofarming, 1932, the Response of Miscellaneous Crops to different kinds of Electrocultural Treatment, p. 14 et seq.

Series III.—The treatments were: *Violet-ray* radiation for 1 minute, the same for 2 minutes, and no treatment for control.

The seeds were Madua, Koni, Linseed, Wheat Pusa 4, Gram K, Sann Hemp, Black Til. Tests were made in Naini Tal, April, 1932.

The superiority of violet-rayed over control seeds was obvious. Radiation for 1 minute gave better results than that for ½. The former has been taken as standard for treatment.

Series IV.—The treatment was x-rays for 1 minute and Control. The seeds were Wheat Pusa 3, Mustard, Wheat Pusa 4, Gram. Naini Tal, May, 1932. Here again the superiority of treated over control was obvious, gram and mustard responding particularly well to treatment.

Series V.—This includes tests with a wide variety of methods on cotton seed. The sowings were largely unseasonal and sometimes exotic.

A. Treatments: (1) Sparking at 3,000 volts for 5 mins. (2) With pocket dynamo, 0·1 amp and 2·5 volts for ½ min. (3) Town supply at 220 volts for 10 sec. (4) Electrolytic, by passing a current from 2 Leclanche cells through 1% common salt solution for (i) 20 minutes and (ii) 45 minutes, and (5) Control.

Germination began in one week and ended in the next. It was 100% for town supply energizing, 80% for sparked, 60% for pocket dynamo, 44% for the electrolytically energized, and 66% for control.

As to *rate of growth*, 3 tests may be applied: the growth of cotyledonary leaf, the number of new non-cotyledonary leaves and plant-height. The order of efficacy of treatment according to these 3 tests respectively is spark, hand-dynamo, electrolytic, town supply; spark, hand-dynamo, electrolytic, town supply; and hand dynamo, electrolytic, town supply and spark. The most effective method is therefore the sparking method.

B. Treatment: X-rays for 2, 3, 4, and 5 minutes respectively and control. The first three gave germination in 4 days, the fourth in 5 days. It is noteworthy that the short exposures are quite as effective as the long ones, which are really useless and finally harmful. One minute has been fixed as standard for x-ray treatment.

C. Broach cotton treated to violet-rays for 1 min., x-rays for 1 min. and control. This cotton is liable to root-rot in Baroda. It was sent after treatment in insulated bags to Baroda[1] and sown there 10 days after treatment. The treated plants were much better than the control ones and the final yield was 90 lbs. for x-rayed seed; 75 lbs. for violet-rayed seed; and 60 for control. There was no root-rot.

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[1] The Baroda Tests were made by Dr. Likhite, of the Cotton Research Laboratory, to whom grateful acknowledgments are made. The Naini Tal parallel tests are reported in Nehru's New Experiments in Electro

D. Seed of Cotton 402 and 52 were treated to x-rays for 1 minute in Naini Tal and sent by post to Muttra[1] where they were sown. The treated germinated in 6 days as against 7 taken by control. The former ranging 69 and 60% as against the latter 59 and 50% respectively. The maximum heights were 163 and 190 as against 137 and 175. The produce per plant 3·97 and 3·85 gr. as against 2·77 and 3·05 gr. respectively.

Resurveying these tests it is clear that x-ray method is excellent for cotton seed which is sent long distances by post, after taking the usual precautions. Sparking is also effective; Radiomagnetic can also be tried with success.

Series IV.—Treatment: (1) Radiomagnetic; (2) Ultra-violet for 1 min. at 1 cm. (with Cooper-Hewitt lamp); and (3) Control.

Seeds: Antirrhinum; Dahlia; Lettuce; Pansies; Poppy; Centauria; and Verbena.

Germination is quickest in ultra-violet bed, then in the radiomagnetic and last in the control. The controls are backward throughout. Radiomagnetic are better than control and ultra-violet as good as the former.

Summing up, experience of seed energetics shows that while all the methods explained give good results, better than the untreated plants, X-ray and Radiomagnetic Methods must be given first place, Ultra-violet a close second, and High Tension Spark a near third.

METHODS OF SOIL ENERGETICS.

These are open to a *prima facie* objection: Why waste energy on the soil? What is there left to choose between the classical methods which waste energy in the atmosphere and the new methods which would dissipate it through the soil? But the objection is not valid: most of the farming operations prepare the soil *physically*; why not also, taking a step further in soil science, prepare it *electrically*, and so open a vista of less fertile and *unfertile soils becoming fertile*? Now[2] preliminary tests with such soils have shown that the sparked

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farming, 1933, on the Improvement of Cotton Cultivation by Electrocultural Methods, p. 3.

[1] The Muttra Tests were made by Rai Sahab Ramprasad Singh, Economic Botanist. working in Cotton and Barley, to whom grateful acknowledgments are made. The Naini Tal parallels are reported in Nehru's Further Experiments in Electrofarming, 1932, the Response of Cotton to X-Ray, etc. Treatment, p. 11 et seq.

[2] Nehru, Experiments in Electrofarming, 1931, tests with treated seed in beds of loam, loam plus sand, half and half, and of pure sand, p. 28.

seed does very much better relatively speaking in the poorer soils than in the better ones. Examine this closely: the sparked seed does not lose its charge or energy by the simple process of sowing, which should just earth or ground it, but retains it effectively as is shown by the better results achieved. So, now, then, why could not the soil itself be energized in the same way and given a measure of energy which should be retained by it, at least for a while, and utilized by the seed when sown soon after?

1. *Tickling Methods.*—These are based on the above principle. The tickler is briefly an apparatus which pumps electrified air, rich in electric ions, ozone, nitrous gases, etc., all obtained by sparking air under pressure, into the soil and sub-soil round the seed or the roots of a growing plant. It consists essentially of a tube, with a conical orifice through which air is pumped, while inside the orifice at its narrow part a high tension spark is delivered in the same way as before. The tube with orifice is inserted at 3 or 4 places immediately round the roots of the plant and this type of tickling done for a minute at each place. (Picture was shown.)

So much for tickling the soil round the growing plant. For tickling the soil in a big field for large-scale operations, the tickler can be easily modified for attachment to a tractor with disc-plough, such that every time a sod is turned electrified air is pumped in at the base before it drops back.

The results of a very wide variety of tests may be considered thus:

Tickling Series[1] *I.*—*Mango*, *jowar*, *broomcorn*, and *bajra* plants were tested in pairs, one tickled and the other kept as control, care being specially taken now as always that the plants in a pair were as nearly alike as possible. Due to tickling the *mango* plants grew very fast, while the control continued dormant. They measured 32 and 27 cm. respectively.—*Jowar* tickled grew from 81 to 270; control from 101 to 230. The former was healthier and better and yielded 1¼ tola seed as against ½ yielded by the latter.—*Broomcorn* tickled grew from 115 to 352; control from 115 to 264, panicles measuring 70 and 60 respectively.—*Bajra* tickled grew in 12 weeks from 64 to 193; control from 61 to 208. The former produced 19 ears and 1½ tola of stout healthy seed; the latter, 11 ears and ¼ tola only.

Tickling Series[1] *II.*—*Chrysanthemums*, *zinnias*, *marigolds*, and *gomphrenas* were selected in pairs and treated as before. *Gomphrena* tickled grew 37 cm., control 36·5, but the former put forth better, bigger and more numerous flowers, as in picture. It also lived much longer.—Zinnias, marigolds, and chrysanthemums gave a similar response to tickling as illustrated.

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[1] Nehru, Experiments in Electrofarming, 1931, p. 42 et seq.

Tickling Series[1] *III.—Potato plants* tickled grew in 12 weeks from 33 cm. to 53 : control, from 37 to 41. In another set the figures were 34 to 52 and 32 to 48 respectively. Tickling increased the yield from 7 to 12 tolas in one case and from 7 to 14 in another. Encouraged by the above, larger scale tests were made with a variety of potatoes, Longkeeper, Field Marshall, and Catie Glover, the tickled behaving much better on the whole. In some cases the control did not grow at all, or where the resting period was very short and the variety peculiar, germinated very late. Tickling hastened germination 50% and increased yield 20%.

Tickling Series[2] *IV.*—Plants smitten with *disease—smut, rust, leaf-curl*—were tickled after transfer in pots from distant fields, in 4 places as usual.—*Smut* in wheat: tickled plant grew from 100 to 107 cm. in a week but the ears fell to black powder. Control was bad throughout.—*Rust* in wheat : tickled plant grew from 71 to 84 in a fortnight, developed 10 ears and yielded 1 and ¾ths tola.—*Leaf-curl* in chillies: tickled plant bore bigger and better fruit (as illustrated).

Tickling Series V.—Sugar-cane ratoon, tickled, grew from 54 to 121 cm., bore 4 shoots, weight 247 gr., sucrose 31·17 gr. Control grew from 60 to 91, bore 1 shoot, weight 124 gr., sucrose 14·67.

Tickling Series VI.—A ½ acre plot of perfect barren land, never under plough and subject to continuous saline efflorescence was watered overnight, given 3 ploughings with a tractor, and 2 more with the tractor-cum-tickler. Sowings were immediately made of jowar, broomcorn, sann hemp and a wide variety of other farm and garden seed. The seeds mentioned germinated normally and well. Ratoons of sugar-cane M 16 also took root. But efflorescences coming up, formed a crust, and killed all growth.

2. *Radiomagnetic Methods.*—These are the same for soil as for seed. Numerous tests have been made. In the *first* series, phlox, candytuft, dianthus, and clarkia seeds were found to give a better response to this treatment than to violet rays. In the *second* series, strawberry plants were treated and found to grow and fruit much better than the controls. They lived much longer and the decaying process shown by browning, rotting, holing of leaves was delayed and less. New leaves also come out profusely when treated. In the *third* series, 20 kinds of flower seeds were tested. Germination was much quickened, and flowering accelerated by 10 to 36 days compared with control. In the *fourth* series, gooseberry plants, treated, grew to 125 cm., with a spread of 125 cm. and 50 berries, while figures for control being 75, 75 and 19 respectively. The berries

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[1] Nehru, Experiments in Electrofarming, 1931, p. 49.
[2] Ditto, p. 55.

were bigger. In the [1] *fifth* series, treated French Beans, Brinjals, Pumpkins, Peas, Indian Corn, Carrots, Radish, Capsicum were found to give a very good response, as in illustration. In the *sixth* series, mustard, oats, patua (Rozelle), and Nasturtium did very much better than control: mustard growing to 177 cm. with big pods and plant-yield ½ tola, as against control, 147, thin pods and ¼ tola: oats, 147 heavy crop, plant-yield 1½ tola and 125, thin crop and ¾ tola respectively: Rozelle, 30 cm. with 10 flowers and 20 cm. with 3 flowers respectively: and Nasturtium, 30 cm. with 32 flowers and 16 cm. with 12 respectively.

METHODS OF PLANT ENERGETICS.

The radiomagnetic method can be modified for plants. Where the wire-netting cannot be made to go *under* the seed or the roots, it can yet be made to wrap *round* the roots of the growing plant, by jacketing or aproning a foot underground and overground. Tests were made extensively: In the [2] *first* series, 80 Bangalore plants received in Lucknow were jacketed for treatment where necessary and the whole lot distributed between 4 centres, whereof one was in the hills. Very good comparative response was given by *Cassia floribunda, javanica, marginata,* grandis; *Anona muriatica, squamosa, palustris, reticulata; Musa textilis; Gliricidia maculata; Clerodendron fallox; Kaempheria Gilbertii; Xephyranthes; Hœmanthis multiflorus; Justicea chrysantha* and *carnea: Coffea arabica;* Cactus Dahlia; *Zizyphus jujuba;* and many others.—In the [3] *second* series, Rose plants in Naini Tal, which are badly affected with mildew and do not develop big flowers, were given this treatment with the result that the mildew improved and the plants bore big flowers.—In the *third* [4] series, Hollyhock plants growing in Lucknow, which are badly affected with a peculiar endemic disease shown in the curling of leaves with browning, profuse holing, rotting and decay, responded beautifully to this treatment as shown in pictures. The new set of leaves was quite healthy in each case treated, while controls were bad as ever.—In the *fourth* series, tall Jacaranda trees jacketed as above were found to gain in vigour, retaining their foliage and green appearance in April when the control ones were getting dry and bare. Indeed when sparked they even put out new shoots.

METHODS OF FLOWER ENERGETICS.

Elaborate tests have been made with a variety of flowers, the treatment being the mildest possible for a few seconds only with a pocket dynamo. The[1] flowers were Daisies, Salvias, Pinks, Marigolds, Geraniums, Golden Rods, Rose-buds, etc. Positive results were obtained throughout, specially noteworthy being, e.g. flowering geraniums which have a delicate critical stage, when the very mild treatment becomes lethal.[2] Rose-buds grow much bigger after mild treatment, as shown by pictures.

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[1] Nehru, New Experiments in Electrofarming, 1933, p. 11.
[2] Nehru, *Ibid.*, p. 4.
[3] *Ibid.*, p. 14.
[4] *Ibid.*, p. 35.

APPLICABILITY OF THE ABOVE METHODS.

This has been a very brief review of the new methods. The questions arise: Can they be easily applied, and if so, by whom ? There is practically no [3] important seed or plant which does not give a good response to some treatment or other and show a marked improvement. The sparking and tickling methods can be easily applied by the amateur or professional gardener, the nurseryman, the market-gardener. The radiomagnetic methods which are extremely simple can be applied by them as also by the ordinary farmer, with this difference that big fields cannot of course be covered with wire-netting. But in such cases seed derived from small-scale cultivation and treatment is available for large-scale tests. But in all cases, it is up to seed depots to supply seed to farmers properly treated and packed in insulated bags. These depots can easily arrange for large-scale treatment. Moreover, for x-ray and ultra-violet ray treatment of seed, it is always possible for the x-ray department of the nearest school, college, university, clinic, hospital or the like to arrange for the very brief treatment, which would cost them nothing, and in fact help to keep the x-ray[1] bulbs or the Cooper-Hewitt lamps in good condition. In that way the additional cost due to treatment would be nominal or very small.

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[1] Nehru, Experiments in Electrofarming, p. 102 et seq.

[2] Nehru, New Experiments in Electrofarming, p. 27 et seq.

[3] Nehru, Alcuni Aspetti Dell 'Elettrocoltura, Istituto Agricoll Coloniale Italiano, Firenze, 1933—XI. Per l'*Orticoltura : Solanum tuberosum, Brassica botrytis, Vicia faba, Soja hispida, Lactuca sativa, Pisum sativum, Asparagus officinalis, Brassica gongyloides, Brassica oleracea, Capsicum annuum, Daucus carota, Cucurbita pepo, Phaseolus vulgaris, Raphanus sativus, Spinacia oleracea, Solanum melongena* and *Beta vulgaris*. Per la *Fioricoltura : Verbena* sp., *Dahlia* sp., *Aristolochia rotunda, Coleus* sp., *Aster chinensis, Anchusa capensis, Rosa acroclinum, Coreopsis auriculata, Satureja hortensis, Centaurea cyanus, Alyssum Benthami, Eschholtzia californica, Clarkia elegans, Gypsophylla* sp., *Dianthus* sp., *Phlox* sp., *Calendula officinalis, Pyrethrum indicum, Pyrethrum sinense, Zinnia elegans, Zinnia multiflora, Gomphrena* sp., *Papaver Rhoas* var. *Shirley, Petunia* sp., *Papaver* sp., *Delphinium ayacis, Cosmos, Antirhinum, Reseda* sp., *Dianthus caryophylla, Nasturtium officinale, Rosa* sp., Per l'*Arboricoltura : Cassia floribunda-nodosa-renigera-grandis, Colvillea racemosa, Gliricidia maculata. Anona palustris, Anona muricata, Eriobotrya japonica, Feronia elephantum, Zizyphus jujuba, Haematoxylon Campechianum, Ilex paraguayensis.* Per la *Frutticoltura : Mangifera indica, Citrus aurantium, Ribes rubrum, Fragaria vesca.* Per l'*Agricoltura : Saccharum officinarum, Sinapis alba, Crotalaria juncea, Linum usitatissim, Zea mais, Phaseolus radiatus, Sesamum indicum, Panicum miliaceum, Oryza sativa, Hordeum vulgare, Gossypium indicum* 402, *Gossypium indicum* 520, *Gossypium herbaceum, Sorghum vulgare, Pennisetum typhoideum, Avena sativa, Pisum* sp., *Triticum sativum, Triticum durum, Hibiscus sabdariffa* (pp. 6–10). Grateful acknowledgments are made to this Italian Institute for publishing my work at its own cost and for distributing it.

CONTACTS.

Specially helpful and welcome have been the[2] contacts made during a very recent visit abroad, while examining the more prominent institutes and discussing with the leading workers. Thus, sparking (and eventually x-raying) cotton seed with a view to killing off insects such as the pink boll-worm and strengthening the seed has found support from the work of Drs. Chiaromonte and Baldassare of the Italian Institute of Colonial Agriculture at Florence. Dr. Britton of the Yale Experimental Station was another excellent contact in regard to killing insects electrically. How radiomagnetic treatment helps plant growth has been seen in (1) the trellising with iron wire of fruit trees in the Gormanno Fruit Station near Milan ; (2) the practice of driving nails into fruit trees which do not bear fruit in the State of Wisconsin, U.S.A. ; (3) the tests on so-called Contact Stimulation by Dr. Stone of Amherst, Mass., U.S.A. ; (4) the powerful growth due to iron sheathing in certain garden plants in Paris, Kew, Jhansi, etc. ; (5) denser growth of forest grass along the marginal track of wire-netting used on certain American Rail-roads such as the Pennsylvania. In regard to the continuance of energizing effect for four generations as observed here so far, a valuable contact was gained with Prof. A. Pirovano of the Rome Institute of Electrobiology. As to the increased growth of certain vegetables as found here after treatment with violet, ultra-violet and other rays, important contacts were gained with Prof. Vladimoff in the Moscow Institute of Electroculture, with Prof. Munerati in Rovigno and Prof. Mezzadroli in Bologna, and with Mr. Borlase Matthews and Dr. Bewlay in the Grinstead Farm and Cheshunt Station in England ; and with Dr. Arthur in the Boyce Thomson Institute for Plant Research at Yonkers, New York. Contact was made with Dr. Borodin of the U.S. Department of Agriculture, who is going to work on mitogenetic rays as key to crusade against cancer with onions, whose extremely powerful electrocultural response was shown in the Indian tests 4 years ago. Then, too, was shown the 85% increased growth in Petunias after brief treatment, which are now being shown in better growth over electric cable by the General Electric Company in the Electricity Building, World's Fair, Century of Progress, Chicago. In the McManis College of Electronic Medicine in Kirksville, Missouri, U.S.A., it was a privilege to watch the work of Dr. Lulu McManis on the growth of electronically selected beans and the effect of electronic water on plant growth ; beans had been giving a good response here too and if electronic water is effective, why not electrified air, as pumped in by the tickler ? This leads to several CRUCIAL QUESTIONS : *Is tickling not really better aeration* ? This is hardly so. Air as such pumped in for a couple of minutes round the roots, plays a minor part, but it is the ions and electricity it carries which play the most important part. Control tests show this.

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[1] Nehru, First Steps in Radiology, p. 179. The soft rays required for electrocultural work will benefit the tube, not injure it.

[2] Very grateful acknowledgments are made to—

Profs. Ferrara, Barotolozzi, Chiaromonte of the Agri-colonial Institute in Florence; Prof. Menozzi Molon of the Agricultural Institute, Milan; Prof. Calvino and Professoress Calvino, Institute of Floriculture, San Remo; Prof. Mezzadroli, Institute of Electrobiology, Bologna; Prof. Munerati, Institute for Beet-culture, Rovigno—in *Italy.*

Prof. Yost of the Agri-botanical Institute, Heidelberg; Prof. Becker, Radiological Institute, Heidelberg University; Prof. Hestermann and Dr. Storck of the Plant Research Institute, Berlin-Dhalem—in *Germany.*

Prof. Kosciusko, Institute of Experimental Botany, Warsaw University; Mrs. Sadwiga Zimieska, Miss Grodzinska, Mr. Zojecnsnoski of the Central Agricultural Institute at Pulavy; and to the Curie Radium Institute—in *Poland.*

Profs. Schlichter, Michael Eurinoff, Wadimoff, Artemieff, and Docents Miss Simon, Protopopoff, Korolkoff of the Pan-Russian Institute for the Application of Electricity to Agriculture, Moscow—in *Russia.*

Profs. Molisch of the Botany Institute, Vienna University, Linsbauer of the Botany Institute, Graz University, and Dr. Unrath of Graz University —in *Austria.*

Messrs. Jackson, Rowland, Nash of the General Electric Co., London; Prof. Blackman and Mr. Legg, his Assistant at Rothamsted, and Sir John Russel, Rothamsted;

Prof. Ruggles Gates of Botany Dept., King's College, London; Dr. Bewlay of Cheshunt Experimental Station;

Mr. Borlase Matthews of Felsted Electric Farm;

Profs. Amery and Sibthorpe and Sir Richard Burn of Oxford University—in *England.*

Messrs. Weix and Theobald of Oconomowoc Canning Co., Wisconsin; Drs. John and Lulu McManis of McManis College of Electronic Medicine, Kirksville, Missouri; Dr. J. C. Burnett of the Burnett Research Laboratories of Alpine, New Jersey; Drs. Molyneux and Schoonmaker, President and Secretary of the Eastern Electronic Research Association, New York; Dr. Borodin of the U.S. Department of Agriculture, Washington; Dr. Arthur of the Boyee Thompson Institute for Plant Research, Yonkers, New York; Dr. Deuber of the Botany Laboratories, Yale University; and Dr. East of Harvard University—in the *United States of America.*

Prof. Huskins of the Botany Department, McGill University, Montreal—in *Canada.*

Has the brief high tension sparking really any effect ? The answer is that undoubtedly it has, considering the positive results obtained throughout, especially such conspicuous ones as the raising of winter wheat, the growing of potatoes out of season, the growth of bamboos, mangoes, during periods of rest. Is the effect electromagnetic ? The effect of treatment on certain seeds having been so far followed right up to the fourth generation, the answer must be again, yes.

Have ultra-violet rays any effect at all? Yes, long, strong exposures are lethal ; short, mild ones beneficial.

Have x-rays any effect at all? Undoubtedly they have a powerful effect, beneficial results from x-ray treatment of cotton have been obtained at so many centres and in so many cases that there is no room for question.

Do treated seed retain their efficacy and if so, why? Tests here show such retention for at least 10 days ; in Italy for at least 2 months. But they should be kept insulated—that is essential. It is a surface effect for certain and very probably also volume effect, but all depends on the seed.

. *Is this radiomagnetic treatment not really a means of giving iron and cannot all improvement be ascribed to it?* That is not so. The effect is very largely, but not wholly, magnetic as has been shown. And then diseased and delicate plants have given a powerful response : to take very random tests on asparagus, cyperus, tomato leaf-curl, hollyhock mildew, rose mildew, sweet-pea mildew, and ever so many more, there can be no doubt that radiant electromagnetic energy is captured and transmitted by the device employed. This is *not negligible* by any means, witness the Moray Radiant Energy Device which captures such energy with a similar antenna and earth in sufficient strength to light a bank of 100 lights for 154 hours. *How can plants pick up the waves that suit them?* It is to be very strongly presumed that the plant has a faculty or selective power which enables it to pick up what waves suit it best. Tests designed to give it only one wave-length and not another are bound to fail, as the antenna is sure to pick up other wave-lengths as well from the atmosphere and transmit them to the plant and so vitiate results.

And finally this question : *Is there anything at all in electro-culture?* We have met strong antagonists and still stronger protagonists, and the general attitude is much more favourably inclined to electroculture than it was 10 years ago. But surveying the vast amount of material available in so many fields all showing positive results, it is impossible to doubt such electro-culture or to attribute them to accident. But then the question arises, *Why have results in the West been lacking in consistency?* The reasons are many : (1) Proper control as between treated and untreated plants is not possible with sufficient rigour when the two sets are kept close by, and yet it is known that the ions from the overhead installation can and do travel great distances according to how the wind is blowing or other factors working. But if the two sets are kept very far apart, many other variables are introduced to complicate the study. The defect is, indeed, inherent in the classical method, which besides being an uneconomic proposition does not lend itself to accurate enough control. (2) The treatments given so far have on the whole been much too severe, in fact, lethal. Whether it is x-rays or ultra-violet rays or any other radiation the dosages in the West have been very strong and long, while those in India have been homœopathic from the very start. That explains the greater consistency of results with the latter. But beneficial results are now being obtained there with mild dosages. (3) Loss of efficacy through handling has been avoided here as seed or plant after treatment has not been handled but kept insulated. In the one case in which such handling took place through inadvertance, no results were registered. In the tests in the West it is not clear whether seed are kept insulated throughout. Apparently they are not, on the presumption that they are bound to be earthed when sown. But the Indian tests have shown that there is a difference ; that, in consequence, insulation is very important. (4) Tests in the West were on a big scale, almost field scale, and it is only recently that small scale tests have come into fashion. Now the position is very simple : application of the *results of tests* should of course be on *field scale ; but not the comparative tests themselves,* as too many factors would begin to vary and the electrical factors would be lost sight of. Hence the Indian tests have, from the very start, been on 1 or ½ or ¼ square metre plots, which have yielded comparable, reliable, results. But right here a caveat has to be entered. It is not to be inferred that this concerns the laboratory or the nursery of the botanist or the biologist or the researcher in applied science merely—no, it is the business of the agriculturist to apply the simple methods that have been explained to such large scale cultivation on the one hand and to utilize small plots for raising better seed on the other. Our practical farmers and farming enthusiasts and proprietors of private demonstration farms and superintendents of state farms and controllers of seed depôts and seed distribution centres will, in the new order of things, themselves get energized and vitalized in the process of distributing vitalized, energized seed, watching the better growth yield and husbandry all round and ensuring that this cheap mode of broadcasting the blessings of electricity to the peasantry is utilized to the full.

New occasions teach new duties—Time makes ancient good
uncouth. They must ever up and onwards—Who
would keep abreast of Truth.

A few Typical Photographs were projected :—Electricity improves growth of plants—1. Seed-energiser. 2. Process of tickling. 3. Summer Wheat, different stages. 4. Onions. 5. Verbenas. 6. Sweet Peas. 7. Mango seedlings. 8. Jowar, Broomcorn, Bajra and Potatoes. 9. Potatoes. 10. Marigolds, Chrysanthemums. 11. Gomphremas. 12. Wheat Rust. 13. Disc plough with tickler tube. 14. Tractor used. 15. Sugar-cane. 16. Leaf-curl in Chillies. 17. Radiomagnetic Cradle. 18. Unseasonal potatoes. 19. Radiomagnetic Strawberries. 20. Soya-beans. 21-22. Rice. 23. Cotton. 24-25. Millets. 26. Bamboo. 27. Millets earing. 28. Gooseberries. 29. Cauliflowers. 30. Beetroot. 31. Kohl Rabi. 32. Grass. 33. Asparagus. 34. Chillies. 35. Carrots. 36. Pumpkins. 37. French Beans. 38-39. Indian Corn. 40-41. Mildewed Roseplants. 42–44. Rose-buds and flowers. 45–49. Fourth Generation mustards and peas. 50–52. Mildewed and cured Hollyhocks. 53-54. Barley. 55-56. Mustard. 57-58. Nasturtium. 59. Cotton and Til growing over metal plate. 60. *Mezzadroli* test with Barley and Peas. 61. *McManis* tests with Beans.

Section of Agriculture.

Abstracts.

AGRICULTURAL STATISTICS.

1. A statistical study of 'Ideal size and shape of plot for sugarcane' based upon tonnage experiment with Co. 213 conducted at Meghoul (Pusa) in 1933.

M. Vaidyanathan, New Delhi.

Continuation of the studies on tonnage experiments with sugarcane Co. 205 at Harpur Jhilli (Pusa) in 1932. Criticism of the last year's experiment and improvement of this year's experiment. Field divided into 4 main blocks of 30 rows, each row containing 8 cuts (each cut $60' \times 3' = \frac{1}{242}$ acre), the whole field subjected to the same treatment. The difference between variances due to blocks and due to error not significant deduced by 'analysis of variance', showing the homogeneity of the soil fertility. All possible combinations of plot sizes varying from $\frac{1}{242}$ to $\frac{120}{242}$ acre are considered in different blocks for their frequency in yields, and coefficients of variation. χ^2 test applied to test the goodness of fit the several distributions and distributions are significantly normal for plot sizes $\frac{1}{242}$ to $\frac{12}{242}$ acre. Coefficient of variation minimum between $\frac{10}{242}$ and $\frac{12}{242}$ acre. Results analysed according to the ratio of length to width of several plot sizes, minimum coefficient of variation arrived at for the ratio between 8 and 15. Ideal size of plot may therefore be placed between $\frac{10}{242}$ and $\frac{12}{242}$ acre with the ratio length to width between 8 and 15 (compare the results of the previous years' experiments, optimum size between 1/20 and 1/30 acre and the ratio of length to breadth between 6·7 to 10·1).

2. 'Covariance' applied to experimental plots at Tocklai tea experimental station.

M. Vaidyanathan, New Delhi.

Explanation of the method of 'covariance', and its applicability to the design of new experiments on the basis of preliminary yields. Comparison of the method with the method of choosing sets of plots with equal yields with illustrations from tea experimental results. Construction of 'covariance' tables and the simplification of arithmetical procedure. Application of the method to 'cattle manure' plots and 'Dark mesai Manipuri' plots.

3. A statistical analysis of rotational experiments with cotton, groundnut and juar in Berar.

P. C. Mahalanobis, Calcutta.

Messrs. D. N. Mahta and D. L. Janoria conducted an experiment during 1923–31 with a view to investigate the most economic rotation of crops for cotton in Berar, with groundnut and juar as possible subsidiary crops. The seasonal effects were very strong and often marked the rotational effects. A crop of groundnut (but not of juar), however, appears to have exerted a beneficial effect on a succeeding cotton crop.

The gross and net profits, prices and costs of cultivation were also analysed. Juar enjoyed a specially advantageous economic position owing to large profits and practically constant prices and costs of cultivation. Cotton earned lowest profits and ran the greatest risks owing to large fluctuations in prices and costs of production. The position of groundnut was intermediate between juar and cotton in every respect.

Improved designs for rotational experiments have also been discussed.

4. A complex manurial experiment on rice in Dacca, 1932.

S. S. Bose, Calcutta.

A complex manurial experiment was conducted at Dacca by Dr. A. T. Sen of the Dacca University for determining the effect of (i) lime, (ii) potash, (iii) magnesium, and (iv) niciphos on the yield and weight of rice-grain and yield of straw. The lay-out of the experiment (which was designed by the author of this note) consisted of 72 plots, and the particular arrangement made it possible to study not only the primary effects of the four principal manurial treatments but also the first, second, and third order interactions between them. It was found that lime and niciphos (but not the other manures) gave good responses with regard to both grain and straw. Potash, however, showed an increase of 20 p.c. in the mean weight of individual grains.

A sampling test with tiller-count in the same experiment indicates that lime, potash, and niciphos (but not magnesium) increase the number of tillers.

5. Effect of different types of soil-covers on the moisture economy of irrigated plantations of *Dalbergia Sissoo* in Lahore Division.

P. C. Mahalanobis *and* S. S. Bose, Calcutta.

Percentage moisture at 5 fixed depths of the soil and under 4 different covers of tree and grass were studied by Forest Research Institute, Dehra Dun, in three experimental plots in Lahore Division. The test was conducted in three different months, April, August, and November over the period 1931 and 1932. The lay-out was a 4×4 latin square in plot No. 1, and randomised blocks in plot Nos. 2 and 3.

In all the three experimental plots grass cover always showed a higher percentage of moisture than either the tree or the grass-tree combination. The moisture content also increased systematically with depth, rapidly in the region 0′, 12″ and more slowly below 12″. The seasonal differences were also considerable.

6. A preliminary note on intervarietal correlation in the rice plant in Bengal.

P. C. Mahalanobis, Calcutta.

Mean measurements of a number of characters for 147 varieties of rice plant grown on Dacca farm sent by Mr. Sharngapani of the Bengal Agricultural Department have been studied in this paper. The mean yield is moderately correlated with the number of tillers per plant, the leaf-length and to a smaller extent with the exsertion length and possibly also with the number of spikes per tiller. The mean yield appears to be, however, independent of the weight and size or shape of grains, the plant-height, the inflorescence length or duration and also of the colour of glumes and kernels or the consistency of the grains.

7. On the effect of pests on the yield of sugarcane and the quality of cane-juice.

P. C. Mahalanobis *and* S. S. Bose, Calcutta.

Rai Saheb C. S. Misra of the Pusa Institute collected data regarding the damage caused to the sugarcane crop by cane-borers and white ants. Four different sugarcane pests, namely top-shoot borer, stem-borer, root-borer, and termites together with 6 combinations of these formed 10 different treatments and the effect of these were studied with respect to the yield of cane, the weight of juice, the sucrose, and glucose contents, etc.

The pests acting singly have been found to cause on an average a damage of 30 p.c. in the yield of cane, and of cane juice, and more than 40 p.c. in the total sucrose content. Of the combinations, top-shoot and stem borers which reduce the cane juice yield by nearly 60 p.c. and the total sucrose content by 65 p.c. as compared to healthy canes.

8. Influence of shape and size of plots on the accuracy of field experiments with rice, Chinsurah, Bengal.

P. C. Mahalanobis, S. C. Chakravortti, *and*
E. A. R. Banerjee, Calcutta.

A uniformity trial experiment with transplanted rice (Chinsurah No. 2) was conducted by the rice research section, Chinsurah, in 1932 with a view to obtain the optimum size and shape of plots for future experiments on the given area. Single seedlings were transplanted 9″ apart on an acre of land and at harvest the whole field was divided into 7,040 plots (excluding border) of size 9″ × 90″ ($=\frac{1}{7740}$ acre) containing 10 plants each. The yields of grain and straw were collected for each individual plot and the results analysed by Fisher's method of analysis of variance.

The S.D. of the smallest plot (9″ × 90″) was 13·69 p.c. of mean. The S.D. decreased as the plot size increased, but the decrease in the magnitude of the S.D. was not commensurate with the loss of accuracy due to the smaller number of replications.

Detailed analysis was carried out with blocks of different sizes, keeping constant the size of individual plots, to find out the optimum size (of blocks) for the elimination of soil heterogeneity in the field.

Contour lines of equal fertility have also been drawn, for a study of the fertility distribution over the field.

9. Uniformity trial in rice.

S. K. Mitra *and* P. M. Ganguli, Jorhat, Assam.

A study of the technique of the comparative field trials in rice under different conditions demanded an experiment to be conducted to determine the size, shape, position, and the number of replications of the sub-plots. At the Karimganj Farm, Assam, the S.D. per cent. varied from 10·01% for 3′ × 3′ plots to ·95% for 54′ × 18′ plots in the sail area. The plots 60′ × 10′ (N—S) in size with about 4 replications were found to be suitable for experimental purposes. In the aus area also the S.D. per cent. was rather low, varying from 7·27% for 5′ × 5′ plots to 1·68% for 60′ × 15′ plots. Plots of the size of 60′ × 15′ with 4 replications and of the size of 60′ × 10′ with 6–8 replications according to the degree of the level of significance were found suitable. As the S.D. per cent. was quite low smaller sizes of plots with proper replications could be adopted according to convenience. It was also found desirable to lay out plots along the fertility gradient and thus eliminate its effect. As a Latin Square could not be completed within a bunded field except for small plots it would be better to have randomised blocks, each block being contained in one field.

10. A statistical analysis of rainfall at Akola.

V. SATAKOPAN, Poona.

This paper deals with a statistical analysis of the incidence of rainfall during the monsoon season at Akola for a period of 65 years commencing from 1868. The polynomial of the 5th degree is fitted to the 31 five-day periods of rainfall from May 22nd to October 23rd for each year. The series of six rainfall distribution constants so obtained are further analysed with a view to investigate any progressive changes in the quantity and distribution of rainfall.

11. A Statistical note on the application of modern methods of field experiments for improving the yield and quality of agricultural produce.

R. S. KOSHAL.

Modern methods of field experiments with particular reference to cotton are described. It is pointed out that old methods of field experimentation were all defective due to the improper lay-out of the experiments, and consequently inadequate statistical analysis of the results. The principles underlying the modern field technique as developed by Dr. R. A. Fisher at the Rothamstead Experimental Station, together with the statistical process applicable to the interpretation of results obtained from such well designed experiments are discussed at length with reference to :—(*a*) Effect of different manurial treatments on the yield and quality of cotton ; (*b*) The effect of weather on the different varieties of cotton.

AGRICULTURAL METEOROLOGY.

12. A statistical study of the maximum temperatures at Poona.

R. J. KALAMKAR, Poona.

This paper deals with the analysis of the maximum temperature at Poona from 1880 to 1931. The coefficient of variability of the mean monthly maximum temperature is comparatively higher for the months of June and October which are characterised by the onset and termination respectively of the south-west monsoon. The values of the correlation coefficients for the neighbouring months of the autumn and winter seasons are high. Regression equations for forecasting temperatures for the five seven day periods, viz. November 27—December 3rd, December 4th–December 10th, December 11th—December 17th, December 18th—December 24th, and December 25th—December 31st are obtained from the weekly temperatures of the preceding four weeks.

13. Studies in micro-climatology—Part I.

L. A. RAMDAS, R. J. KALAMKAR, *and* K. M. GADRE, Poona.

In this paper the scope of 'micro-climatology' is summarised; a brief account of different types of measuring instruments for studying 'micro-climates' is then given. Later, the variation of temperature and humidity in the 'open', and inside 'jowar' and 'sugarcane' crops as observed during the first half of December, 1932 at the newly started Agriculture Meteorological Observatory, Poona, are discussed.

14. Studies in micro-climatology—Part II.

L. A. Ramdas, R. J. Kalamkar, *and* K. M. Gadre, Poona.

This paper gives a discussion of the equivalent potential temperature inside and outside a few crops. This is followed by an examination of the statistical relationship between the dry bulb and wet bulb temperatures and vapour pressure in the ' open ' and inside a few crops recorded during the last winter. Conditions at the epochs of ' minimum ' temperature and ' maximum ' temperature are discussed in detail.

Certain suggestions for further work are made at the end of the paper.

15. Studies in micro-climatology—Part III.

L. A. Ramdas, R. J. Kalamkar, *and* K. M. Gadre, Poona.

During two selected periods of last winter, hourly observations of dry bulb and wet bulb temperatures, vapour pressure, and percentage humidity at various heights above ground and hourly observations of soil temperature at different depths were taken for a number of days. These data are discussed.

16. A thermo-couple installation for measurement of air, soil, and plant temperatures.

P. K. Raman, Poona.

For the measurement of air temperature a series of thermo-couples provided with specially designed radiation-proof screens was fixed on a post 10 ft. high. For the measurement of soil temperatures another series of thermocouples was embedded in the soil after suitable insulation of connecting wires under the soil. The connections from all these thermocouples were led into a hut by means of a bare wire net work fixed to insulators. The terminals were connected to a sensitive galvanometer through a specially devised switch-board. The observer sitting inside the hut can thus take a whole series of measurements in a very short time. The whole equipment was made locally at a comparatively small cost. The paper concludes with a discussion of the observations taken during a few months.

17. The evaporating power of the air layers near the ground at 100 selected stations in India.

P. K. Raman *and* V. Satakopan, Poona.

The evaporating power of the air layers near the ground at 100 representative stations in India for different months of the year has been calculated theoretically from the meteorological factors, and monthly charts have been prepared. The paper concludes with a discussion of available experimental data. The importance of recording evaporation at a large number of stations in India is stressed as this meteorological factor is of great agricultural value.

18. Evaporation and its measurement by means of simple Open-pan Evaporimeter.

N. M. Athavle, Poona.

For the measurement of evaporation an instrument consisting of a metal tank one square foot in cross section and 10″ deep provided with a side tube fitted with a micrometer gauge has been designed. Special arrangements have been made to minimise the effect of solar insolation at the sides of the vessel and to minimise disturbance at the water surface due to wind while taking observations. Some observations recorded at the Agricultural Meteorological Observatory at Poona are discussed.

SOILS, MANURES, AND FERTILIZERS.

19. Movement of 'Kalar' or 'soluble salts' in Sind soils.

V. A. TAMHANE *and* B. T. MULVANI, Sakrand-Sind.

It has long been suspected that in saline soils, the soluble alkali salts move from plot to plot. At the Agricultural Research Station, Sakrand (Sind), two adjacent plots with equally high salt contents responded differently to cultivation. On one the crops flourished, while on the other, they failed and also the soluble salts content had increased.

An attempt to determine the cause of this difference in behaviour showed that the two plots differed widely in the nature of their profiles, one of them being sandy and the other clayey. On watering, the soluble salts had been more easily washed down to the lower layers in the sandy than in the clayey soil. Further, the salts from the sandy soil had moved laterally in the sub-soil and accumulated in the clayey layers of the adjacent plot, where gradually, they were brought up to the surface due to capillary movement of water.

20. A broad outline of genetic classification of soils with special reference to field technique suitable for tropical soils.

J. K. BASU *and* S. S. SIRUR.

Definition of terms used. Modern concept of soil. Description of some soil profiles examined by the authors in Europe and India. Development of field technique and rapid laboratory methods for the study of soil profiles.

21. Factors responsible for the fertility of black cotton soils.

J. K. BASU *and* V. D. TAGARE.

General conditions limiting the availability of nutrient materials to plants. Some physical and chemical tests for determining the fertility levels obtaining in these soils. Importance of soil colloid studies in this connection.

22. Attempts to increase the manurial value of the insoluble phosphatic manure—Apatite.

N. V. JOSHI *and* S. C. DUTT, Pusa.

Apatite is available in large quantities in the province of Bihar and Orissa but the phosphate in the apatite is present in an insoluble form. Attempts were made to bring it into soluble form by composting with green manures, oilcake and sulphur—charcoal, but probably owing to the presence of iron and aluminium oxides, only a very small percentage could be citrate soluble. Even the strong sulphuric acid rendered only 4·2 per cent. of the total P_2O_5 water soluble and 10·9 per cent. citrate soluble.

As different crops are known to vary in their ability to derive phosphate nutrition from insoluble phosphates, experiments were made in growing Marwa (*Eleucine coracana*) mustard and wheat. Of these wheat did not respond to apatite or a sulphuric acid treated apatite. Marwa responded to apatite and acid treated apatite to a slight extent but the yield of mustard was 64 per cent. above the control with apatite alone and 370 per cent. above the control with acid treated apatite.

It is concluded that too much importance need not be attached to the chemical analysis of water soluble or citrate soluble P_2O_5 in phosphatic manures. Presence of SO_4 ions may render the insoluble P_2O_5 available to some crops.

23. The availability of soluble phosphatic fertilizers in typical rice and cotton soils of the Central Provinces.

D. V. Bal *and* R. N. Misra, Nagpur.

Experiments to ascertain the changes which soluble phosphates undergo, and the period for which they remain in a water soluble and citric acid soluble condition, after they are added to moist soils have been described.

It was found that in the case of black cotton soil, the entire quantity of the added water soluble phosphoric acid was converted into a water insoluble form after a period of 50 hours, whereas in the case of *Sehar* soil after a period of 70 hours about 3% of the added soluble phosphoric acid was still found to be in a water soluble state.

In the case of *Sehar* soil, even after a period of 8 weeks about 50% or more of the added phosphoric acid remained in a citric acid soluble form, whereas in the case of black cotton soil the percentage of citric acid soluble phosphoric acid after the same period was found to be about 30 to 40.

From the results it appears that under field conditions in the case of *Sehar* soil (which is deficient in calcium carbonate and exchangeable calcium) a higher percentage of phosphoric acid is maintained in an available form to the rice crop than that which is available to the cotton crop grown on black cotton soil rich in calcium.

24. Studies in the methods of estimating nitrogen in the rice soils.

N. S. Bamji, Bombay.

A study of the nitrogenous changes in the rice soil during the crop season is interesting. This necessitated the use of very reliable and easily workable method of analysis. It was, therefore, undertaken to test the efficiency and reliability of various methods of estimating total nitrogen in various substances and find out a suitable modification for soil analysis.

During the investigation different methods gave varying results under different conditions. From the results of analysis, Kjeldahl method with various modifications gave not only the best but the most consistent set of results. The efficiency of various oxidising and heat producing reagents was tested and the most suitable reagents found out. The efficiency of trapping acids was also put to test and various techniques of work were made use of and adopted both for digestion and distillation.

25. Root system—its importance in the manurial investigation of sugarcane.

R. D. Rege *and* P. V. Wagle, Padegaon.

The authors are of opinion that intelligent manuring of sugarcane requires a knowledge of the behaviour of the root system which is found to differ greatly in the different varieties. They further suggest that manuring is a varietal problem and should be tackled accordingly. The paper is illustrated by photographs.

26. Protozoan fauna of Lyallpur soils.

S. M. Nasir, Lyallpur.

Different types of soils, viz. clay, loam, and light loam were examined by plating out on agar nutrient medium. The following types of protozoa were found :—

Nœgleria Gruberi. Hartmanella hyalina. Nuclearia sp. Cercomonas sp. Bodo saltans. Tetramitis spiralis. Oikomonas termo. Colpoda cucullus. Colpoda Steinii. Balantiophorus elongatus. Gonostomum affine. Pleurotricha grandis.

27. Nitrogen in rice plants under different manurial treatments.

B. L. Desai, Bombay.

Maximum growth, yield and carbohydrate contents in rice plants treated with a mixture of ammoniacal and nitrate nitrogen were obtained by two investigations in the Royal Institute of Science. Encouraged by this it was undertaken to study the total nitrogen content of the rice plant during its entire life history when treated with sulphate of ammonia, nitrate of soda and with a mixture of the above named in equal proportions. These in untreated plants were also studied.

As a result of trials, boric modification of Gunning method for total nitrogen and magnesium oxide method of A.O.A.C. for ammonia were adopted.

The results of the first year of analysis show the highest total nitrogen content in plants under mixture treatment. Plants treated with mixture show highest ammoniacal nitrogen content in October, though for the rest of the season there are very small differences in all treatments.

28. Studies on cotton in Central India and Rajputana. The influence of manures and the surface texture of the black cotton soil upon yields.

Yeshwant D. Wad, S. B. Mogre, *and* V. N. Bhargave, Indore, C.I.

1. It has been shown that at least half the effect of continuous manuring in garden lands appears to be the improvement of the soil texture.
2. Openness of soil up to 6 inches depth is essential for the best development and yield of seed cotton for both Desi and Cambodia cotton on the black soils of Malwa.
3. Cambodia under such open-soil conditions grows free from disease in spite of prolonged wet conditions.
4. As a rain-grown crop (Cambodia Indore 1) is easily surpassed in acre-yield by Malvi 9, to the extent of 50 to 100%, due to the closer spacing of the latter.
5. The superiority of composts made by the Indore process over farmyard manure has been clearly indicated.

29. Estimation of nitrogen in soils.

A. Srinivasan, Bangalore.

It is well known that the different modifications of the Kjeldahl method now in general use are unsatisfactory. The process of digestion is often prolonged over several hours : even then it is incomplete (particularly in the case of heavy clay soils of which 25 per cent. remain as such), the undigested particles being protected by a sheath of silica from further action of the acid. Researches carried out with the object of eliminating the above defects show that (*a*) the use of diluted (1 : 1) sulphuric acid in place of the concentrated one facilitates thorough penetration of the soil particles and prevents the formation of the protective coat and (*b*) addition of small amounts of oxidizing agents (preferably hydrogen peroxide) together with the acid helps to complete the digestion of even the heaviest soils in under half-an-hour. Further work directed towards developing a satisfactory technique to include nitrates is in progress.

30. Biochemistry of water-logged soils. Mineralization of organic matter.

A. SRINIVASAN, Bangalore.

Studies on transformations undergone by different organic materials commonly used as manures under water-logged soil conditions have shown that (1) there is some relation between the chemical composition of the substance and its mineralization though the decomposition is not entirely dependent on the carbon-nitrogen ratio of the material concerned; (2) the C : N ratios of the decomposing substances tend to become the same for all substances, the rate of such change being rather slow for substances of wide carbon-nitrogen ratios than for those with narrow ones; (3) there is progressive loss of nitrogen in all the cases, the loss being more rapid in the case of substances of narrow C : N ratio than those of others; (4) the nitrogen is lost mostly as ammonia; (5) the percentage loss of carbon or of nitrogen is governed also by the total quantity of the manure added, being more with large quantities than with smaller ones; (6) the addition of mixtures of materials brought to a C : N ratio same as that of the soil greatly minimises nitrogen losses, and (7) ammonification of the added material is somewhat favoured by slightly acid (controlled) conditions and nitrification by alkaline conditions.

The mechanism of decomposition with special reference to the formation of organic acids and the dissolution of minerals, particularly silicates, is being investigated.

31. Effect of manure on the yield, fibre properties and spinning quality of cotton.

D. L. SEN *and* NAZIR AHMAD, Bombay.

The paper embodies the results of an investigation on the influence of different manures in respect of yield, chemical constituents, physical properties and spinning quality of cotton. For this purpose, the material used was Cambodia Co.2 grown in two successive seasons (1928–1930) in neighbouring plots under different manurial treatments.

The results indicate that cotton, grown in a plot in which a particular soil deficiency is made up by means of a suitable manure, not only shows a greater yield but a marked improvement in the chemical constituents and physical properties; on the other hand, excessive manuring on a fertile soil has a decidedly depressing effect. Furthermore, although no significant differences were observed in the yarn strength results of cottons grown under different manurial treatments, in several cases the manured samples gave less neppy yarns than the unmanured ones. The differences in fibre properties, etc. due to soil variation have also been discussed.

PLANT PATHOLOGY.

32. Homœopathy as applied to one phase of agriculture.

V. A. TAMHANE *and* M. A. SHAMA IYENGAR, Sakrand-Sind.

The homœopathic system of therapeutics is based on the theory that 'disease is cured by remedies, which produce on a healthy person effects similar to the symptoms of the complaint of the patient, the remedies being usually administered in minute doses '.

Further, in the practice of manuring, the quantities of the essential principles added are extremely small compared to those already present, even in the poorer soils. Yet the plants respond to these minute impulses, as it were.

The common factor of the 'minuteness of the doses' in both the cases was rather striking. This gave rise to the speculation, if the homœopathic principles of healing could be utilised to serve the necessities of plant life.

There was considerable mortality of plants in saline soils. May be the plants developed certain fatal symptoms due to the salts in the soil. Were it so, it should be possible to save them by administering identical salts in minute doses. By the same law, if a plant already affected by those symptoms be then sown in a saline soil, it is as probable that the salt in the soil may now prove harmless or even a remedy.

To test this, seeds were treated with salt solutions of different homœopathic concentrations and sown in sand cultures containing different percentages of the same salt. The germinations were studied and certain interesting results obtained.

33. Collar swelling in areca palm.

T. N. Sen, Assam.

Collar swelling in areca palm—a new disease—is being noticed sporadically mostly in young trees in Assam for about four years. The affected trees become stunted in growth with distinct collar swelling, and curled and pale coloured leaves. The diseased bud rots and the plant dies within a year or two. The disease is noticed to be confined in the collar portion only.

One species of Thiellaviopsis has been isolated from the affected portion. Inoculation experiments from same gave negative results. The local people incise the swelled portiòn with a *dao*, whence a gummy substance oozes out and the tree becomes temporarily cured. But once cured it is liable to be attacked again. This is under further study.

34. Relative susceptibility of cotton to wilt.

G. L. Kottur *and* S. S. Maralihalli.

Cotton wilt is caused by a species of soil fungus, identified as *Fusarium vasinfectum* Atkinson.

Almost all asiatic types of cotton, which are now extensively cultivated in India, are highly susceptible to the attack of the fungus.

The disease is, at present, very serious in Bombay and Central Provinces, but the spread of the trouble to other presidencies is probably a matter of time.

Some of the commercial varieties, though susceptible, contain resistant elements in them. Such varieties yield, by selection, resistant strains which breed true to the character. They also improve, as a result of continuous growing on wilty soils, which helps in preserving only those individuals which resist attack. The improvement, in many cases, is rapid as the disease kills a large number of susceptible individuals in the early stage of their growth.

35. Studies in disease resistance with special reference to cotton wilt.

G. L. Kottur *and* M. K. Desai.

The behaviour of resistant selections in cotton and jowar is described. Selection resistant to red leaf blight broke down to some extent as a result of the change in the feeding habit of the insects concerned. Striga resistant selection in jowar though not completely immune is constant for its degree of resistance. With regard to wilt it is found that almost all indian cottons are susceptible to it. Selections which are highly resistant are, however, obtained in certain varieties. The resistance in these cottons is constant when tested under the heavily infected conditions of the field. The same selections when grown under the controlled conditions in the green house suffer badly in all cases. Even the immunity of the American cotton which is very clear in the field is affected in the green house. In this case the parasite enters all the plants irrespective of their behaviour in the field. The mere invasion of the organism, however, does not mean susceptibility, as a certain number of plants succeed in checking any advance of the fungus and grow normally. This capacity to smother the disease is regarded as resistance. Different degrees of resistance are mentioned and their importance in breeding is emphasized.

36. Strangulation rôle in the deaths of cotton plants in Gujarat.

M. S. Pandya *and* A. F. Patel, Baroda.

While observing the cotton root-rot on the Baroda agricultural experimental station, deaths were seen to occur amongst cotton plants due to 'strangulation'. The soil is Goradu (light sandy loam) and becomes extremely hard after the rainy season is over. Root strangulation under these circumstances may not be surprising. This course of death roll amongst the plants was observed rather late in 1932-33 season. Hubbard has mentioned this phenomenon from California as root-constriction. Further observations will be taken in due course.

37. Cultivation of sugarcane mosaic virus in vitro.

S. V. Desai, Pusa.

Experiments were devised to induce the multiplication of mosaic virus in vitro. Tissue culture and other methods failed to give a culture which reproduces the disease. It was found that the transfers of the mosaic virus in series in alkaline broth induces a capricious pleomorphic growth. The juice of healthy tissue failed to give similar phenomenon. Similar behaviour was observed in repeated series of duplicated experiments. The organisms so isolated gave very minute colonies in the beginning. The individual colonies on transfers showed a high percentage of non-cultivability on all solid media but gave a hazy growth in broth on prolonged incubation. On further transfers the growth of well established spreading large colonies was established. These colonies had many plaque like clearings in them.

The biochemical reactions of the organisms varied unaccountably and the growth in all of these standard culture media was meagre and slow. All attempts to separate organisms into well defined separate types of organisms failed. The organisms obtained from sugarcane mosaic virus differed in biochemical reactions from those obtained from tomato mosaic but the growth characteristics and other cultural behaviour were found to be similar.

Attempts to reproduce the disease by incubating these cultures into sugarcane have so far been unsuccessful. As long as the conditions which adversely affect the virulence of the sugarcane mosaic virus are not understood, the artificial transmission with material kept in vitro is likely to be unsuccessful.

38. Some experiments on the control of loose smut (*Ustilago tritici*) (Pers) Jens. of wheat.

J. C. Luthra *and* Abdus Sattar, Lyallpur.

The loose smut of wheat occurs commonly in the Punjab and in some parts the damage caused by it is as high as 10–20 per cent.

Simplified hot water treatment, single-bath method and two other new methods in which solar energy is used are described in the paper. A brief outline of the methods evolved is given below :—

Simplified hot water treatment method :—(i) Wheat is presoaked in unheated water at 60°–85°F for 4–7 hours. (ii) It is then dipped in water at 120°F for five minutes. (iii) Finally it is immersed in water at 127°–132°F for 7 minutes. (iv) It is then thoroughly dried and sown immediately or can be stored till sowing time.

Single-Bath Method :—Soaking of seed wheat in water at 105°F, 110°F, and 115°F for 8, 6, and 4 hours respectively gives a complete control of the smut.

Sun-heated water method :—A blackened cylindrical galvanized iron vessel, 30 inches long and 16 inches in diameter half filled with water, is placed in the sun in the morning on any bright sunny day in summer and seed wheat is soaked in it from 12 noon to 4 P.M. and then dried.

Solar energy method (exposure of presoaked wheat to the hot sun) :—Seed wheat is soaked in water for four hours (8 A.M. to 12 noon) on any bright summer day ; then taken out and exposed to the sun for four hours (12 noon to 4 P.M.). Maximum temperature in shade at Lyallpur goes up to 120°F and in the sun it has been recorded up to 131°F in June.

GENETICS AND PLANT BREEDING.

39. An efficient method of selfing crop-plants.

T. C. N. Singh, Sabour.

In crop-plants selfing is usually done either by covering the plant as a whole or one of its flowering branches by thin muslin bags of desirable mesh. But it is often necessary (in crops like Sunn-hemp) to apply mechanical means to ensure pollination between flowers on the same plants. This is best done by introducing in the bags the right type of insect or other agents which bring about pollination in nature. Of course extreme care should be taken to free these agents from pollen grains before introducing them in bags.

The author is confident that this method could easily be extended to cases where a large number of crossings have to be made simply by judiciously changing the pollinating agents from one desired bag to the other.

By this device considerable time and waste of energy and worry can be saved.

40. Polyembryony in rice (*Oryza sativa*).

K. Ramiah, N. Parthasarathi, *and* S. Ramanujam, Coimbatore.

There are only three reported instances of polyembryony in rice. Kumaro in Japan, Rodrigo in Philippines, and Jones in America noted but one instance each of twins arising from one seed and regarded this phenomenon as of very rare occurrence.

The authors have observed this feature occurring regularly in a pure line, 1 in 1,000 seeds giving rise to mostly twins and occasionally triplets, the occurrence of the latter being recorded for the first time in rice. This phenomenon was a regular feature in the hybrid progenies involving this pure line as a parent, while it was only of very rare occurrence in others. Examination of the twins has given some interesting information about the possible origin of polyembryony in rice. Apart from cases where the twins were identical there were others, one from the pure line throwing a haploid and a diploid, and others from the hybrid progenies giving rise to a lethal albino and a normal green or two lethal albinos. It is surmised that in rice, apart from other possible sources, polyembryony might arise by fertilisation of more than one egg. Cytological studies dealing with the subject are under way.

41. Inheritance of root colour in rice.

B. S. Kadam, Karjat (Bombay).

A Burmese variety of rice develops red colour on roots when exposed to sunlight. Crosses made with a colourless variety show that the character is dominant and in F_2 a ratio of 9 coloured : 7 colourless is obtained. In F_3 some of the F_2 plants breed pure, some segregate like the F_1 and others give a monogenic ratio of 3 coloured: 1-colourless. The colourless types breed true. A gene R_r produces colour on the roots and functions only in the presence of the major gene A, without which no colour can be produced in any part of the plant.

42. Linkages in anthocyan pigment factors in the rice plant.

K. Ramiah, Coimbatore.

The mendelian inheritance of the presence and absence of anthocyan pigment in various parts of the rice plant has been recorded at Coimbatore and elsewhere. It has been established that the presence of pigment in any part of the plant depends upon the presence of two complementary factors. In addition to these two, there are several other localisation factors which control the development of pigment in the various parts as leaf-sheath, leaf-axil, internode, leaf-junction, auricle, ligule, internode-septum, fertile glumes, apiculus, stigma, etc. The presence of pigment is always dominant to its absence but the number of factors involved in each of the above is sometimes one, two or more.

The paper records the inheritance of a large number of these factors not recorded hitherto, and discusses the relationship among them. So far about 26 separate pigment factors have been recognised and their inheritance indicates the presence of four linkage groups. One of these groups as represented by the special variety of rice with deeply pigmented, almost blackish, internode, glume, leaf-junction, auricle, ligule, rice, etc. is found to contain a large number of these factors. The factors comprising each of these four groups are detailed.

43. Study in rices of Bihar and Orissa. The biology of flower and the effect of various climatic factors on the opening and closing of the spikelets and bursting of anthers.

M. Alam *and* R. A. P. Trivedi, Sabour.

The time of opening and closing of flowers and bursting of anthers has been studied in some detail in a number of paddy strains, differing in time of maturity and also under diverse climatic and growth conditions. From this study, which has been continued for two seasons, some definite conclusions, as indicated below, have been arrived at.

The time of opening and closing of flowers seems to differ a good deal with early, medium, and late varieties and is influenced to a great extent by the atmospheric humidity. Dehiscence of anthers appears to take place just in the process of opening, but in certain late varieties it was observed to occur a few minutes after the opening of flowers. This is likely to be of great economic importance in so far as hybridization work is concerned as it would facilitate emasculation very much.

The effect of temperature, humidity, light, etc. on the opening and closing of paddy flowers has also been studied both in field and laboratory conditions and the results so far arrived at are very interesting. Light does not appear to play any important rôle in the opening and closing of flowers, while the effect of temperature and humidity seems to be a very potent one. A definite correlation between percentage of humidity taken at a fixed hour in the day and the time of opening of flowers has been established.

44. Sterility in Sunn-hemp (*Crotalaria juncea L.*).

T. C. N. Singh, Sabour.

The author, in the course of his study on the Bihar and Orissa Sunn-hemps, has come across the occurrence of the interesting phenomenon of sterility displayed in that crop in various degrees from partial to complete. Completely sterile plants are shorter in stature and bear minute acicular leaves crowded together into numerous buds and are at the same time characterised by a complete absence of flowers but the leaves borne on their lower branches are quite normal. The partially sterile plants though not much different, have flowers showing all sorts of prolific abnormalities. In some, petals are sepaloid and the androecium and gynoecium remain coiled in a peculiar fashion; while in extreme cases the gynoecium has been found to have proliferated into a branched shoot recalling the condition obtained in completely sterile plants.

From a careful study, the opinion is held that in morphological terms the sterility in the case described, is largely due to the proliferation of the gynoecium into very much branched shoots, a situation reminding the state of condition observed in berseem (Singh, T. C. N.: *J.I.B.S.*, IX, p. 250, 1930).

An investigation of the cause of this peculiar sterility both from the genetical and physiological view points is in progress.

CROPS.

45. Seasonal fluctuations in the rice plant.

T. R. Khadilkar, Mugad (Dharwar).

In this note an attempt is made to point out the nature of seasonal fluctuations in the mean values of 12 characters of a strain of rice grown at Mugad Rice Breeding Station. These fluctuations are the deviations from the mean of six years' results and are represented graphically for comparisons of the following nature :—

(i) The graphs that agreed in their trends with others from year to year were as follows :—

Graph of	Varied directly with	Varied inversely with
Number of tillers per plant.	....	1. Weight and number of fertile grains in the main panicle. 2. Panicle length. 3. Number of fertile grains per gram.

Graph of	Varied directly with	Varied inversely with
Date of flowering.	Average straw weight per plant.	....
Number of sterile grains in the main panicle.	Number of undeveloped grains in the main panicle.	....

(ii) Values of coefficients of variability of the annual means of different characters showed wide variations from 46·93 down to 4·09.

(iii) Relations of monthly rainfall with the seasonal fluctuations were :—

Rainfall of	Varied directly with	Varied inversely with
July ..	Culm height.	....
August ..	1. Weight and number of fertile grains in the main panicle. 2. Panicle length. 3. Number of fertile grains per gram.	Number of tillers per plant.
October ..	1. Date of flowering. 2. Average straw weight per plant.	....

(iv) Monthly average maximum temperatures had the following relations :—

Temperature of	Varied directly with	Varied inversely with
July ..	1. The same characters August above. 2. Culm height.	As under rainfall of July above.
August ..	Number of primary branches in the main panicle.	....
October ..	The same characters as under October above.	....

46. Some observations on the varietal composition of the cotton crop in the low lying parts of fields.

B. B. Mulchandani, Parbhani (Deccan).

In connection with the Botanical Survey of the cotton crop in Parbhani and Nanded districts in H.E.H. the Nizam's dominions, where *Gossypium hirsutum* Mill, *G. indicum* Lamk, and *G. neglectum* Gammie comprised almost the entire cotton crop, it was observed that in the low-lying portion of a field the population of the plants was thin, and that its varietal composition was different from that of the remaining part. The proportion of the plants of the different varieties in the depressions and normally situated parts of field was recorded in seven villages.

The data indicate that in the low-lying parts *G. hirsutum* Mill is able to survive better than *G. indicum* Lamk, and *G. neglectum* Gammie. As between the two Indian species, *G. indicum* Lamk seems to suffer less damage. Of the four varieties of *G. neglectum* Gammie, namely, *rosea*, *cutchica*, *vera* and *malvensis*, *rosea* is most susceptible.

47. A study of some economic characters of the cotton boll in relation to the flowering period and branching.

C. Jagannatha Rao, Nandyal (S. India).

In the paper are embodied the results of an analytical study—botanical and statistical—of some economic characters of the 'Northerns' cotton boll, such as shedding interval, maturation period, seed and lint weights and lint length in relation to the flowering period and to the development of the flower on primary or secondary fruiting branch. Data presented pertain to two pure strains of the 'Northerns' cotton, grown at the Agricultural Research Station, Nandyal, South India, during the season 1930-31. The paper is concluded with literature relating to the subject.

48. A preliminary investigation on the germination of sugar cane setts.

R. D. Rege *and* P. V. Wagle, Padegaon.

In order to find out the optimum conditions for the maximum success in germination which is one of the important factors controlling yield, a few experiments have been conducted so far which have given the following definite indications:—

(i) The top setts not only give the highest percentage success in germination; but 60 to 70 per cent. of the total germination results within the first three weeks. This figure is from 20 to 30 per cent. for the bottom setts. It must be remembered that the hastening of germination is one of the important conditions for maximum success as it would prevent the inroads of such pests as white ants, fungus, etc. which generally abound in soil.

(ii) Application of sulphate of ammonia at the time of planting instead of after three weeks as in the standard Manjri method helps to hasten the germination and eventually leads to higher success—the more so in the bottom setts. This procedure is therefore specially recommended wherever the whole plant cane is used for planting.

49. Germination in sugarcane as influenced by rind hardness and soil moisture content.

I. A. Khan.

Tests have been carried out during the two cane seasons with a number of varieties differing in their rind hardness as far as it is related to germination in cane. The following varieties were experimented upon :—Cos. 331, 326, 304, 302, 300. 285, 214, and 213.

The results have conclusively shown that rind hardness bears no relation to the germination capacity or energy of a variety as realised in the field as well as in pot culture experiments. But some varieties have behaved differently in pots as in the case of Co. 326, a variety having *Saccharum spontaneum* blood in it. This has been attributed to the higher moisture requirements of the variety for its satisfactory germination. It has been discussed in detail.

Moisture content variations have shown that germination is greatly influenced by this one factor, and that different varieties behave differently under varying conditions of soil moisture.

The more the wild Saccharum blood in a variety, the better it seems to be placed in a soil with higher moisture contents. Even the soil at saturation point has been tolerated and rate of germination enhanced in case of direct descendants of wild Saccharum. Other varieties do not seem to tolerate this saturation and do best in soil with 15 to 20 per cent. moisture. It therefore follows that every variety or a group of varieties has a different optimum soil moisture for its germination.

This study will prove valuable in so far as it will indicate what type of moisture should obtain in soil for a particular variety. That we need such a knowledge and pretty quickly too, is apparent since the trend is to breed and select varieties not 'panacea' for all but 'specific for each' environment. Giving out different purpose varieties requires this sort of preliminary knowledge about them, since it is too well-known that uniform and quick germination in a field means thrifty growth.

50. A preliminary note on the classification of cultivated Indian mustards.

T. S. Sabnis *and* M. G. Phatak, Cawnpore.

The cultivated Indian mustards belong to *Brassica juncea* L, *Brassica compestris* L, and *Brassica napus* L. They have been classified. The principal works on the subject have been reviewed in the introductory chapter.

The species have been divided into varieties which have again been subdivided into types—nine under *B. juncea*, twenty-three under *B. campestris*, and four under *B. napus*.

The species and their varieties are fully described and a key to the types have been worked out. The localities from which the original seed samples were obtained are recorded in the key. This information will be helpful in understanding the geographical distribution of the Indian mustards.

The representative plants of different varieties and of the new types have been fully described.

The appendix contains a few observations on cultivation, flowering, and pollination of these mustards.

51. Flowering of Coimbatore canes in the United Provinces.

H. N. Batham, Cawnpore.

The flowering of sugarcanes is of rare occurrence in Northern India. In 1931-32 certain varieties of Coimbatore canes flowered on a large scale in the United Provinces. The effect of flowering on the quantity and the quality of the cane was studied by taking random samples of flowered and unflowered canes of almost the same size separately and simultaneously for expressing and analyzing their juice at different dates.

The cause of this irregular flowering of canes was traced to certain weather conditions.

By counting and measuring green open leaves, a relation is traceable between the weight of juice expressed and the number of leaves and their surface area.

The conclusions are: I. Flowering does not appear to reduce the tonnage nor the quantity of juice but tends to increase both. II. Flowered canes are better in sucrose content than those not in flower. Generally the difference in sucrose content of flowered and unflowered canes is of more than one per cent. III. The amount of glucose is found to be appreciably less in the flowered ones. IV. A correlation may be established between the number of leaves and their surface area and the percentage weight of juice expressed. V. Heavy rainfall combined with high temperature and low humidity can induce arrowing in sugarcanes in Northern India.

52. Studies on cotton in Central India and Rajputana. Varietal reaction to date of sowing.

KUBER SINGH *and* YESHWANT D. WAD, Indore, C.I.

Very high yields as compared with those of the normal rain-sown and irrigated crop are obtained with both Desi and American cottons simply by sowing two weeks in advance of rain. The influence of post-rain irrigation is not appreciable. Desi cottons under all treatments gave higher yields than the American varieties tested.

The low yields of cotton usually obtained from the rain-grown crop on the black soil areas are due neither to actual soil poverty nor to intrinsically low yielding varieties, but rather to the unfavourable conditions of growth at the time when rain-sown plants are most susceptible to adverse environment.

ELECTRICITY AND AGRICULTURE.

53. Moradabad parallel cultivation tests in Electro-farming.

VISHNU SHARMA.

The work started was in Moradabad under directions of Dr. S. S. Nehru to do parallel cultivation of some plants which were being tried at Dr. Nehru's electric farm in Lucknow.

First Series. To show response of some flowers and vegetables to Radio-magnetic treatment.

Dahlia, Pansy, Verbena, Centauria, Antirrhinums, Poppy, Salad, and Pea were tried.

Seeds sown on 27th January, 9 A.M.

The results have shown better growth of treated plants.

Second Series. To show effect of sparking on some vegetables and flowers.

Sparked seed of Maize, Onion, Lobia, Cornflower, and Sweat sultan sown on 17th February, 9 A.M.

The treatment enabled early germination and better growth in out of season period.

Third Series. Growing of hot and rainy season plants in radio-magnetic bed.

Sunflower, Gulmanhdi, Jania, Brinjal, Palak, Cotton, Til, and Urd were tried. Sown on 27th July, 7 A.M.

The experiment has so far given good results. It is under progress.

Fourth Series. To show response of Barley and Gram to sparking, radio-magnetic, and violet ray treatment.

Laid on 19th September, 1933.

Seeds did not come out due to almost continuous rain after sowing.

54. Preliminary investigations on the effect of electrical treatment in increasing crop yield.

C. Maya Das *and* S. N. Chatterji, Cawnpore.

Experiments were conducted by the authors to study how far electrical treatment of crops is possible, and economically sound under large scale field conditions. A simple and inexpensive apparatus was evolved and tried on wheat, oats, and gram. A technique for use of the apparatus invented was developed. The experimental results indicated that energisation of crops in the manner suggested by the authors is a financially paying proposition at current market rates of wheat. The experiments further suggest a new line of attack to meet the menace of the present low level of prices of agricultural commodities in general. by increasing the yield of crops under farm conditions at a nominal cost.

55. Response of sugar-cane to electrocultural treatment.

Purshottam Das.

Some cuttings of Co. 213 canes were sparked at Lucknow by Dr. S. S. Nehru and transported to Rae Bareli in rubber bags and were sown untouched with hands in two trenches on the 23rd February, 1933. Two more trenches were sown with the cuttings of the same seed-canes on the same date with no treatment to serve as control. Manuring, irrigation, and hoeing, etc. were all alike in both cases.

The crop is now ready but the treated canes are decidedly superior to the control in growth, yield, and quality. The yield expected from the treated canes will at least be double that of the control.

It is therefore evident that sparking improves the yield and quality of sugar-cane which is confirmatory to Dr. S. S. Nehru's results and also that the effect of sparking is not lost in transit if carried in insulated bags.

PLANT PHYSIOLOGY.

56. Some chemical and physiological studies on wheat throughout its life-cycle.

P. C. Raheja.

The growth rate increases throughout the life-cycle of wheat plant in general but increases at a higher rate towards the end of the growing period when ripening is hastened under the climatic conditions of the Punjab. The rate of increase of crude fibre corresponds with the rate of growth of the plants.

The respiratory activity at first continues to fall from 1·10 c.c. to 0·376 c.c., when at the earing stage it again rises to 0·768 c.c. followed by a steady fall in the ripening stages.

A very high negative value of the coefficient of correlation of—0·91 ± 0·0102 is obtained between the growth rate and respiratory activity per gramme of dry matter.

The ash content decreases in shoots slowly from 15·6 % in the beginning of February to 6·41 % in the beginning of April. Conversely the N_2 in the plant increases from mid February (1·27 %) to early March (2·04 %) when it rapidly falls to 0·26 % in the first week of April. Moreover there is almost a linear relationship between N_2 and P_2O_5 in the growing plants.

pH value of the plant juice decreases in earlier stages from 6·47 to 5·7 which remains constant till the maturity of the crop.

57. Effect of the type of manure on weekly water requirements of wheat and barley.

P. C. RAHEJA.

With the application of farm-yard manure barley could utilize low moisture contents most economically than wheat manured similarly or with ammonium sulphate, although the latter treatment to wheat produced the greatest amount of dry matter.

The maximum weekly loss of water was exhibited at the earing stage (5th week from the stage of tillering) after which the rate of loss began to decrease in all the series accompanying the ripening of the crop.

The degree of the total amount of water utilized more or less determined the maturation period of the crop. Farm-yard manured barley was the first and farm-yard manured wheat was the last to mature.

58. The effect of different salts on the germination of wheat.

V. A. TAMHANE *and* J. J. CHANDNANI, Sakrand (Sind).

The kalar or salt lands of Sind are known to contain a varying proportion of different salts, the predominating salts being Sodium Chloride and Sodium Sulphate. (Salt lands containing deposits of Sodium or Potassium Nitrate are also found which are used as manure.) In order to ascertain the injury done to the plant life by most of these salts from the earliest stage of the plant growth, experiments were carried on to see the effect of some of these salts, e.g. Chlorides, Sulphates and Nitrates of Sodium, Potassium, Magnesium, and Calcium on the germination of wheat seed in pure sand. It was found that weight for weight Magnesium Chloride was the most harmful of all the salts, Sodium Chloride standing next in point of injury whereas Sodium Sulphate hardly did any damage in as high a concentration as 0·6%.

Solutions containing equivalent weights of salts in which the concentration of Chlorine ions was kept constant showed that the injury done to the germinating seed was not quite similar but varied with different basic radicles; this point is being further investigated.

Of all the salts tried Potassium salts exerted a more beneficial effect on the germination of wheat seed.

The germination was retarded as the concentration of the salts used increased.

59. Water requirements of rice plants.

P. M. GANGULI, Jorhat (Assam).

Experiments were conducted at the Karimganj Farm to estimate the water requirements of rice plants under different conditions. Investigations were carried on to determine (i) the effect of different kinds of soil on water requirement, (ii) effect of different classes of rice on water requirement, (iii) effect of fertilisers on water requirement, and (iv) the effect of temperature on the rate of transpiration. Water requirement was somewhat higher in the loam soil than in the clay soil although the difference was not distinctly significant. The different types of rice behaved differently with regard to their water requirements which varied directly with the length of the growing period of the different types from 445·58 to 613·4. Water requirement for the different fertilisers was also different. It was least in the unmanured and most in Ammophos being 557·5 and 727·4 respectively. Except with slight variation the rate of transpiration followed closely the daily temperature.

60. Study in rices of Bihar and Orissa. The root system of paddy under different soil and growth conditions.

M. Alam *and* A. R. Akhtar, Sabour.

The study of the root system of paddy under different conditions of growth is in progress at the Rice Research Station, Sabour. It comprises of 3 distinct aspects of the question, i.e. (*a*) the root system as affected by different manurial treatments at seedling stage, (*b*) the effect of applying different doses of common salt on the root system of paddy, (*c*) the root-system of paddy grown under different soil conditions such as ordinary clay, red laterite of Chotanagpur, old alluvial of localities round about Gaya, black cotton soil of Singbhum (Chaibasa) district and others.

In the first case, different amount of phosphoric acid was applied to the seed bed as follows :—(*a*) Super double, 100 lbs. per acre, (*b*) Super double, 150 lbs. per acre, (*c*) Ammophos 200 lbs. per acre, and (*d*) control. It has been found that Ammophos at 200 lbs. per acre produces darker seedlings than with other treatments and the root system of such seedlings is also better. The final yield from the crop raised by transplanting these seedlings is also significantly higher. The study of the root system of the seedlings treated in the seed bed with different doses of common salt ranging from ·7/2 to 2·1 has also been done and it is observed that ·7/2% salt treatment produces better root system than the rest, including the one without salt. The root systems of seedlings grown under different soil conditions also differ to some extent and the results so far obtained indicate the possibility of making suitable selections for different localities on the basis of root system.

61. A short note on the comparative physiology of cane varieties in North Bihar.

P. C. Raheja.

Physiological suitability of a variety gives an insight into its being a success or otherwise in tiding over the external atmospheric and soil conditions in accordance with its internal rôle of life processes continually working in the plant. A preliminary investigation was therefore conducted to compare the behaviour of some of the promising varieties now grown in North Bihar.

It was observed that the stomata, though they make a variety drought-resistant or otherwise, have only a suppressive effect on the rate of water loss from the leaves and have a regulatory function to perform in the conduct of CO_2 from outer atmosphere to the inner tissue system.

Low root respiration in CO. 205, CO. 285 and Co. 326 is suggestive of their hardiness to withstand unfavourable conditions of soil such as water-logging, soil drought, etc. While low leaf-respiration of Co. 213, Co. 210, and Co. 313 indicates high efficiency of manufacturing processes in the plants.

62. Importance of compact seed-bed for cereals of Bajri and Jowar.

V. G. Gokhale *and* K. R. Patel, Poona.

A loose seed-bed such as is obtained by ploughing the light soil of the Deccan to a depth of 8 inches in the month of December or in subsequent hot weather months and left without any further tillage till the beginning of the following rainy season has been found to kill the sprouts of about half the number of seeds which are normally expected to survive in the case of *bajri* and *jowar* crops in the *kharif season*. Although the probable inference is that the looseness of the soil aggravated the loss of soil moisture in the germinating zone so as to bring it below the critical point experimental evidence is lacking for the verification of the inference.

Groundnut, san, kulthi, cotton, sesamum, mug and niger seed were not found to suffer under conditions similar to those in which jowar was found to suffer. Working the soil with a heavy log harrow or cultipacker immediately before sowing packs it sufficiently to give a normal stand.

Incidentally, it has been noticed that half the stand gives very nearly the same final weight of yield as the normal stand.

AGRICULTURAL ENTOMOLOGY.

63. Insect phototropism and its economic importance in India.

T. V. RAMAKRISHNA AYYAR *and* K. P. ANANTANARAYANAN,
Coimbatore.

Studies on the behaviour of organisms, and especially on that of insects, have formed the theme of many eminent zoologists in the past and yet there exist numerous points in the different aspects of the subject which offer avenues for further investigations. The study of insect tropisms is one of these, and though a good deal of work has been done by eminent workers like Loeb, Wheeler, Morgan, and Jennings in the west, the study of the complex tropic reactions of insects in the Indian region has received hardly any serious attention so far. This paper is the result of some preliminary studies recently started to study one aspect of the various insect responses.—viz. Phototropism with special reference to South Indian Insects, and indicate its economic bearing.

To an agriculturist the study of Entomology is solely a utilitarian one, particularly with an aim to control his crop pests. Next to a knowledge of the life-history of the insect pests the study of their behaviour, their adaptations and responses to environments and external stimuli forms one of the main lines of work for finding ways and means of control on scientific and economic lines.

The paper includes a preliminary survey of the different kinds of insects exhibiting phototropism in S. India and some observations on those which have an economic importance.

64. Moth borers of sugarcane in South India.

T. V. RAMAKRISHNA AYYAR *and* V. MARGABANDHU,
Coimbatore.

The chief borers of cane in S. India are the cholam stem borer *Chilo zonellus* S, the ragi borer *Sesamia inferens* WLK., the white tip shoot borer *Scirpophaga nivella* F, and the chief moth borer *Argyria sticticraspis* Hmpsn. The paper, after giving a short account of each of the above borers, deals mainly with the chief moth borer of cane in this province—*Argyria sticticraspis* Hmpsn.

The paper gives a short life-history of the borer and treats at some length the nature and extent of damage—especially to young shoots and to primary shoots in the early stages and its effect on the yield at the end; the effect of damage to mature canes and to young seedlings raised from seeds in the breeding stations. The several factors which determine the degree of incidence of the borer are also discussed, chief among them being (1) the effect of seasons and weather such as rainfall, drought, and the time of planting; (2) *cultural* such as the effect of different manurial treatments, spacing, guntaka workings, etc.; (3) *topographical* such as relation of the fields and the degree of incidence; (4) number of shoots put forth; and (5) varietal susceptibility. Mention is also made of the natural enemies and measures of control so far tried.

The paper, on the whole, is an ecological study of the pest which might help us in dealing with it on rational and economical lines.

65. Epilachna beetles and their control.

M. AFZAL HUSAIN *and* S. ABDULLAH SHAH, Lyallpur.

Grubs of *Epilachna* beetles (*Coccinellidæ*) known as '*Hadda*' in the Punjab, cause serious damage to *brinjals* and other Solanaceous plants.

Two species of these beetles (*Epilachna dodecastigma* Muls. and *E. vigintiocto-punctata F.*) are only pests of the egg-plant and not that of cucurbits as believed by some. There is a third species which resembles *Epilachna dedecastigma* in the number of its dots, but is otherwise quite different in appearance, is found exclusively as a pest of cucurbits.

Any how all the species resemble each other with regards to their life-history, habits and control.

Bionomics, food plants, and control of these beetles have been studied.

66. *Batocera rubra*, Linn (Fig borer).

M. AFZAL HUSAIN *and* M. ABDUL WAHID KHAN, Lyallpur.

Batocera rubra Linn. is a very destructive pest of the fig trees in the Punjab; it also attacks the mango and the apple trees. On account of its ravages many an orchard has been completely devastated. The beetles come out from the beginning of May up to the end of August. They lay eggs, singly, by making a slit for this purpose by means of their mandibles and pushing the eggs in these, so that it is completely embedded into the bark, and in rare cases only, its one pole is exposed. The grub hatches out within 7 to 14 days, and tunnels in the bark without exposing itself out. The path is zigzag and the tunnel is filled up with the woody fibre and faecal matter. Later on, it enters the inner wood and becomes full grown in about 6 months. Pupation takes place inside the stem and the beetle emerges out in about 4 months by boring out its own passage. One life-cycle is completed in a year.

The pest can be successfully treated by :—(i) protecting the stem with wire-gauze in the egg laying period. (ii) capturing the beetles and killing the eggs in the slits by means of a nail, (iii) killing young larvæ by means of a nail or a knife, (iv) injecting kerosine oil into the holes from which faecal matter, etc. is coming out in abundance.

67. Observations on the Palm weevil *Rhynchophorus ferrugineus* Fb. as a pest of coconuts in Cochin.

C. S. VENKETASUBBAN, Cochin State.

The Palm weevil, *Rhynchophorus ferrugineus* Fb., does not seem to be a pest is the conclusion arrived at, as a result of a series of observations extending to nine years. The insect is generally prevalent in gardens affected with the diseases 'bud rot' and 'stem bleeding'. What are alleged as 'weevil attacks', are usually noted to be trees infested primarily with these diseases, and attract the insect only later on. The weevil is very rare in places, where these diseases are not prevalent. The statement that 'the holes bored by the palm beetles—*Oryctes rhinoceros* are taken advantage of by the weevils for oviposition' is practically found to be not true. Neither the steps notched by toddy tappers, nor other shallow wounds, afford access to the weevils. The wounds have to be deep and decaying, if at all, any weevil is to get attracted to them.

The weevil seems to be not a pest, but only an agent to warn us against neglect of trees affected with diseases like 'bud rot' and 'stem bleeding', and deep wounds causing decay of the stem.

68. An unusual infestation by *Lepismidae*.

M. Afzal Husain, Lyallpur.

A serious infestation of a large house by *Lepismidae* was reported from Lahore. On enquiry it was discovered that the infestation started from a store of dry wheat-flour-loaves, which had been stored for sale as food for cattle. Details of this infestation are described. The pest did considerable damage to cotton and silk garments, crawled into beds, fell into food, and generally made it impossible for the occupants to stay in the house. They had to move out. Placing newspaper painted over with flour paste containing sodium fluosilicate was recommended, but it appears that the pest died out by itself rather than through the control measure suggested.

69. Why do locusts eat wool ?

M. Afzal Husain *and* C. B. Mathur, Lyallpur.

The locusts are notorious for their voracity and they have been known to eat such unattractive substances as window-frames, felt tents, luggage, window-blinds, curtains, and even clothing hung for drying. There is a case reported in which the locust swarm, in one night, ate up the wool from a flock of sheep so that they appeared carefully sheared. Experiments were made to discover what made a vegetarian insect like locust eat up wool. It has been determined that this is done to quench their thirst. It is only moist wool which is eaten.

70. Colour change at sexual maturity in *Schistocerca gregaria* Forsk.

M. Afzal Husain, Lyallpur.

The adult *Schistocerca gregaria* Forsk., belonging to the gregarious phase, are salmon-pink in colour on emergence. This pink colour, however, soon turns into brownish or greyish-brown and becomes darker with age. When the fliers reach sexual maturity the general colour turns bright yellow, particularly in the males. It was generally believed that the maturation of the sex gland was responsible for this change. To study this question experiments were performed by removing the testes and ovaries of the 5th stage hoppers belonging to the gregarious phase, caught from bands in November, 1930. Most of the hoppers stood the operation very well and in due course moulted and became adults. These desexed individuals developed the normal bright yellow colour of the gregarious adults. The males showed greater intensity of yellow coloration than the females. From this it is clear that change in colour does not depend on the maturation of the sex glands, but is independent of the very existence of glands. In nature the two phenomena—maturation of the sex glands and change of colour occur more or less concurrently.

71. Insecticides and their use in India.

T. V. Ramakrishna Ayyar, Coimbatore.

Among the various methods of controlling pests of different kinds the use of insecticides is one. The indiscriminate use of sundry drugs, washes, decoctions, and miscellaneous recipes of various kinds has been in vogue to check plant pests of different kinds from the days of our ancestors. Though the author stated in his previous paper on some local methods regarding insect pest control in S. India—*Agricultural Journal of India,* 1921, that there might exist a few really effective pest control substances among the mass of such local recipes, the bulk of them have been found to be quite ineffective quack nostrums of village charlatans and mountebanks. It is only since the initiation of agricultural improvements on scientific lines during the early years of this century that pest control measures on rational lines came to be adopted and among them the use of some well-known and reliable insecticides used in the Western countries came into practice. Though in the case of staple food crops like cereals grown on extensive areas in this country the use of insecticides is not as yet a practical proposition the few attempts made here and there to treat some pests on paying commercial crops like tobacco, chillies, fruits, and vegetables have produced encouraging results; and since now-a-days more attention is being paid to the scientific raising of some of these important crops the use of insecticides appears to have a promising future among pest remedies. In this paper an attempt is made to review briefly the past experience in the use of some of the insecticides, point out the present position with regard to insecticides in various aspects—such as cost, easy availability, purity of materials, etc., and finally indicate the future possibilities of insecticides and the desirable moves on the part of entomologists, biochemists, and governments to keep up this important aspect of pest control on a sound and reliable basis as in some of the western countries.

72. A very destructive caterpillar pest of stored products in South India.

P. N. KRISHNA AYYAR, Madras.

This paper is an attempt to present the results of an investigation extending over a year on the common Lepidopterous insects infesting stored agricultural products in South India. These insects are of special interest and importance on account of the great loss sustained annually by their depredations. Unfortunately these have been insufficiently studied in the past in South India and considerable confusion exists at the present moment regarding the species concerned, their exact identity and relative importance.

From observations and available records a brief survey of the chief caterpillar pests occurring in this province together with a comparative estimate of their economic status is made. Among these *Corcyra cephalonica* Staint. is seen to be the most abundant and destructive species in this province. Practically little is known regarding the biology of this insect from available literature. Hence an intensive study of this pest was carried out during 1932-33. An account of the life history of this pest including its habits, food range, distribution, longevity, fecundity, developmental instars and their duration, etc. is recorded for the first time in detail. Considerable variation in the total length of its life cycle in different food materials such as Sorghum, Ragi, Maize, Tenai, Rice, Rice flour, Cowpea, Cotton Seeds, Groundnuts, etc. is found to exist. Observations on the number of yearly generations, seasonal activities and probable causes of heavy incidence are also presented. The paper concludes with a brief description of the more important methods of prevention and control together with the results of a few preliminary tests on the relative efficacy of certain fumigants against the eggs of *Corcyra*. It has been found that carbon bi-sulphide in sufficiently large doses may yield satisfactory results.

73. A new pest on moringa in S. India.

C. J. GEORGE, Bombay.

Moringa buds are attacked in South India by a caterpillar of a species of *Noctuelia* which bores into the buds and eat the essential organs. As a result of the attack buds instead of blossoming shed. During bad seasons as much as 50% of buds are shed.

This insect is easily differentiated in the caterpillar stage from *Noorda blitealis* which attacks leaves and inflorescences, by its smaller size and reddish body. The general colour of *N. blitealis* is a dirty green, though when it is about to pupate it changes into a beautiful pink colour. The moths are also distinguished by the size Noorda being much bigger. The coloration and markings however are not very differentiating.

The moths lay their eggs on the leaf stalks or slender stems. The larvæ after hatching out bore into the tender buds and feed on the inside organs. When the buds are shed they pupate on the ground. Advanced larvæ though not fully mature are capable of pupating. This is a provision to ensure safety of the race.

The remedial measures advocated are very practicable and effective. The shed buds are easily gathered and destroyed along with the larvæ inhabiting them. By such continued destruction the attack could be minimised.

MISCELLANEOUS.

74. Agricultural planning and rural reconstruction.

N. G. Apte, Poona.

Rural reconstruction has attracted a great deal of attention. This includes the moral and mental well-being of the villagers. The rural worker has got certain programmes for which he wants money in large amounts. This amount is so large that it cannot be made up by contributions and donations. For this the country has to produce more so that some extra money may be created for the reconstruction work. Introductions such as cotton and groundnut brought in more money, but that was chiefly in the boom period and chiefly depended on the foreign purchaser. As a result of the depression and low prices the cultivator collapsed together with his cattle, due mainly to disproportionate cropping. This state of affairs affected the cotton area (Khandesh) adversely, and rich men became paupers. In order that such circumstances may not repeat specific planning based on the requirements of the nation has to be made and all the apparatus that is required in this national plan has to be locally manufactured. Unless this is done the plan will not work properly to completion. None of the steps in the manufacture of the apparatus should depend on others including raw material. Such a plan when successful would give enough returns to finance rural or, for the matter of that, any reconstruction work that may be taken up.

75. Use of molasses in making silage from different fodder crops.

N. V. Joshi, Pusa.

Addition of molasses up to 10 per cent. was tried in making silage from Kudzu vine, *Pueraria Thunbergiana*, Dhub grass, *Cynodon dactylon*, mixed lawn grass, and Berseem with and without oat straw. It was found that molasses hastened the lactic fermentation, brought about a rapid increase in hydrogen-ion concentration and total acidity and thus rendered the silage less liable to damage by other fermenting organisms.

76. An aroma producing organism isolated from Indian dairy products.

N. V. Joshi *and* C. S. Ram Ayyar, Pusa.

In the search for organisms which produce good aroma in butter, several Indian dairy products were examined and of the many organisms isolated, was found one which produced high volatile acidity in milk and milk plus citric acid and large quantities of diacetyl in milk plus citric acid, but none in milk alone.

When inoculated in pasteurised milk and cream the organism produced good aroma in the curd and butter. It grows well at 21°C, coagulates milk with little acidity and is a citric acid fermenting Diplococcus.

The paper further describes the cultural and morphological characteristics of the organism and the results of cream ripening experiments conducted with it.

77. Brown Trout (*Salmo fario*) in the Punjab.

M. Hamid Khan, Punjab.

Salmo fario introduced in the Kulu Valley streams has established itself in the river Beas and its tributaries and is now breeding wild in nature. Brood fish kept at the hatcheries are stripped every year. The egg measures 4 to 6 mm., development depending upon the temperature of water takes several weeks, eyes appear after 5 weeks. The eyed-ova are hardy and can be transported for stocking the streams. Hatching takes 12 weeks, and 30 days later the yolk sac is absorbed and the fry begins to feed.

Trout ova have been planted in all the tributaries of river Beas in Kulu and Kangra. In river Ravi the plant has been made near Chamba. In river Sutlej the stocking has been done in its tributaries situated in Simla hills. Tributaries of river Jumna situated in Rampur Bashar State have also been stocked.

Kulu streams are full of animal food for the Trout. Flies with aquatic larvæ are represented by Trichoptera, Ephemeridæ, Diptera (Chironomus, Simulium, and Dixa), Plecoptera and Odonata. To obtain accurate knowledge of food eaten by Trout in Kulu the stomachs of several specimens have been examined. Their food mostly consists of larvæ of caddis flies (Trichoptera) eaten with their cases, of May Fly (Epheneridæ) Beetles (Coleoptera), Stone Flies (Plecoptera), Blepharoceridæ, Chironomus and Dixa. Shells of Molluscs are also common. One specimen caught from a side stream had a semi-digested frog in its stomach.

Interbreeding for the last 25 years has deteriorated the rate of growth and has produced three grades of coloration.

78. Disappearance of colonies from count media.

R. Rajagopalan, Bangalore.

Quantitative studies with a number of soils on a variety of biological media have shown the following :—(1) Colonies disappear from all count media that have been so far devised. (2) The numbers that disappear vary with different soils and are in some cases as high as 15 per cent. of the final counts. (3) The colonies first appear in the early stages of incubation, generally within the first three days. In a short time, they turn first translucent, then increasingly faint until they fade out altogether at the end of about a week. (4) It has not so far been possible to cultivate the disappearing organisms owing to the fact they generally die out before the fading of the colonies can be observed.

The significance of the above phenomenon in relation to (*a*) the accuracy of the present methods of enumerating different soil micro-organisms and (*b*) disintegration of microbial cells resulting in their ultimate transformation into plant nutrients is emphasized.

79. The use of sodium chlorate for the destruction of weeds and undesirable plants.

A. V. Varadaraja Iyengar, Bangalore.

Lantana camara is a pest in many parts of India. Till now all attempts to eradicate it by mechanical means and through insect agency has not been encouraging. It appears possible to eradicate it only through cultural methods such as the introduction of certain species, like bamboo, which is in progress in Madras, or through the action of chemicals applied in some form or another. A number of experiments have shown that sodium chlorate is very effective in killing lantana. Improvements in the technique of application with special reference to the elimination of the fire hazard are in progress.

In the case of spiked sandal plants, sodium chlorate is also effective and the action of spreaders on the effectiveness of the chlorate is under experiment.

80. Preservation of mangoes.

B. N. Banerjee, Bangalore.

In continuation of work already done since two years, it has been found that mangoes can be stored equally well by dehydration, syruping and canning. Canning of mangoes has not been given the study it deserves, and the small amount that is being produced is of poor quality. The selection of the proper fruit at the correct stage of ripeness is very important. A profitable plan would be to collect the season's fruits, assort it according to variety, ripeness and condition of the fruit, and use them accordingly. The mangoes that have suffered any mechanical or other injury should be ripened quickly and consumed as such. Such of them as are free from defect should be canned, or conserved with spices. Those that are in perfect condition should be cold stored or utilized for export. Fully ripe mangoes can be dried in a current of hot air and preserved as dry pulp. Ripe and soft ones can be stored in the form of concentrated juice. By proper selection, a variety of useful preparations can be made, and a good deal of wastage prevented.

81. Hydrogen ion concentration and preservative action on mango juice.

B. N. Banerjee *and* K. Sapta Rishi, Bangalore.

In the course of experiments on the storage of mangoes it was found that the P_H of the juice was one of the factors that determined fungal attack. It has been observed by others that the toxicity of several preservatives depends on the P_H of the medium. To test the same in the case of the mango, media were prepared from ripe juice whose hydrogen ion was regulated to P_H 2, 3, 4, 5 and 6. The preservatives, Sodium Benzoate, Sodium Salicylate, Sodium Sulphite, Formaldehyde, Boric acid and SO_2 were tried at various dilutions. The fungi tested for were Asp. Niger, Pen. Glaucum (2 types), mycoderma, wild yeast, and B. Coli. Except the last one all the cultures were isolated from rotting mangoes. Sulphur dioxide, benzoate, and salicylate are satisfactory at a P_H 3 to 4 at a concentration of about 0·1%.

82. On the fluctuations of subsoil water-table.

V. I. Vaidhianathan *and* H. R. Luthra, Lyallpur.

The question whether the subsoil water is drawn up to the surface of the earth and from what depths is of importance in waterlogging and in the growth of plants. In a locality where the water table is 21 feet deep, investigation shows that more water evaporates from a surface exposed to the sun than from a surface which is kept unexposed.

Hourly observations taken through observation pipes sunk into the water-table show that the water-table reaches a maximum depth at 12 noon. There is also a second maximum reached at 6 P.M. Between these there are also two minima the range of fluctuation is within half an inch. It thus appears probable that water is being drawn up, though in small quantities, to replace the loss due to evaporation from the soil surface. Further experiments in different areas where there is no disturbance of the subsoil water-table by either pumping or irrigation are in progress.

83. Some improvements in the plate method of counting soil microflora.

R. RAJAGOPALAN, Bangalore.

Although it is unsatisfactory in several respects, the plate method is still the most reliable technique for enumerating the number of living cells in any biological medium. In the case of the soil the method offers special difficulties because (*a*) it is exceedingly difficult to get uniform suspensions, particularly with certain types of soils, (*b*) all the living cells, particularly those present in soils which have been stored for some time, do not form colonies so that the counts obtained for them are always less than they should be and (*c*) several of the colonies (in some cases as much as 15 per cent. of the total number) formed in the earlier stages disappear on further incubation. With a view to obviating the above defects a number of experiments were carried out, as the result of which it has now been found that (*a*) the use of a 0·1 per cent. solution of agar in sterile tap water or saline gives more uniform suspensions than water alone and (*b*) allowing the soil to stand in contact with the dispersing fluid for at least half-an-hour gives higher and more consistent counts than the usual method of plating immediately after the preparation of the suspensions. Further researches leading to the improvement of the technique are in progress.

84. The effect of mosaic virus on algæ.

S. V. DESAI, Pusa.

The effect of mosaic virus on unicellular algæ was taken up with a view to see what effect the virus has on chloroplasts in the algæ cells. It was found that the juice of mosaic leaves stimulated the growth of the algæ. The juice of healthy leaves had no appreciable effect on the growth under similar conditions. The juice of mosaic leaves lost the growth promoting quality if heated for 5 minutes at 80°C. One-hundredth part of a cubic centimeter of the juice was sufficient to induce this phenomenon. These effects were confirmed in several series of experiments. The alga tried, was identified as belonging to the order of Pluerococcus and the Genus Chlorella.

Section of Mathematics and Physics.

President :—Prof. S. K. Mitra, D.Sc.

Presidential Address.

Transmission of Radio Waves round the Earth.

Gentlemen,

It has been customary on the part of a Sectional President of the Indian Science Congress to take up as the subject of his address some branch of the department of science which his section represents and with which he is familiar as a result of investigations carried out by him. Following this time honoured custom I shall deal with the problem of the transmission of radio waves round the earth in my address this morning. For the last few years we in Calcutta have been trying in our humble way to contribute something towards the elucidation of certain aspects of this fascinating problem.

The Problem.

The problem of the propagation of radio waves may be stated in the form in which it appears to the wireless engineer. It is simply this. At any point on the surface of the earth an aerial of given shape and size is traversed by an electric current of a given intensity and frequency. It is required to find out the strength of the radiation field at any other point on the surface of the globe. The problem is of great practical importance to the wireless engineer, because, he wants some sort of a guidance in designing a transmitting station which is required to maintain 24 hours communication with a distant country and the erection of which involves the expenditure of millions of rupees. To the mathematician and to the physicist the problem is equally interesting. The former can employ with great advantage the weapons at his disposal in solving the problem as presented to him in an idealized form by the physicist and the latter by his skilful experiments can trace the physical agencies which are responsible for bringing to grief the theoretical deductions of the former.

The investigations, theoretical and experimental, prompted by the search for a solution of this practical problem, are mainly responsible for the extension of our knowledge and a better understanding of the mode of propagation of the radio waves. Our knowledge in this direction might be said to have advanced in two stages. The first stage covering the first two decades of the present century saw the solution of the problem of propagation round the surface of a conducting sphere and the establishment of the theoretical-cum-empirical formulas of the Austin-Cohen or Watson-Eckersley type. The second, the present stage beginning with the advent of the short-wave towards the close of the second decade, sees the formulation of the Eccles-Larmor theory and the development of powerful methods of investigating the conditions of the ionised upper atmosphere, or—to call it by its modern name—the Ionosphere[1], which plays such an important part in carrying radio signals round the earth.

I shall begin by giving a brief historical outline of the development of the theory as made in the first stage before the advent of short-wave.

Early Attempts to solve the Problem.

Ever since the days (1901) when Marconi succeeded in sending wireless signals across the Atlantic physicists and mathematicians have been trying to find out the mechanism by which the wireless waves could be deviated from their straight course and reach the opposite coast of Atlantic overcoming the curvature of its surface. The explanation which was naturally put forward was that the phenomenon was one of diffraction like the phenomenon of sound waves reaching points behind an obstacle by getting round its corner. The early attempts of mathematicians and physicists were therefore directed towards solving the problem of the propagation of radio waves round a curved conducting surface. The formula which forms the starting point of any theory or discussion on propagation of electromagnetic waves is the classical one of Hertz[2] derived in 1888 expressing the field strength at any point round an oscillating electric doublet. This formula is so important to the radio-telegraphist that I shall briefly explain its implications here.

An electric doublet consists of two equal and opposite kinds of charges separated by a distance. Its strength is defined as the product of the charge and the distance separating the two charges. Around such a doublet there is a steady electric field, the strength of which at any point can easily be calculated from the principles of electrostatics. At points the distances of which are large compared with the distance between the charges the strength of this steady field varies inversely as the cube of the distance. Further, the energy contained in the field is inherently associated with the charges; if the charges disappear the energy disappears. If, however, the strength of the doublet be not constant, if it be varying with time then the field around the doublet assumes a very much more complicated form. In addition to electric field magnetic field appears and these travel out with the velocity of light. The fields can be shown to have five components, two magnetic, and three electric which can be conveniently designated as H_1, H_2 and E_1, E_2, E_3. The fields H_1 and E_1 vary inversely as the distance from the doublet. The fields H_2 and E_2 vary inversely as the square and the field E_3 inversely as the cube of the distance from the doublet. The fields H_2, E_2, and E_3 predominate at short distances from the doublet but at great distances these fields are practically non-existent and the only fields remaining are H_1 and E_1. These are the fields known as radiation field by means of which radio communication is carried. The components H_1 and E_1 are always at right angles to one another, and always fluctuate in the same phase. Their mutual directions with respect to the direction in which the dipole is situated are such that in accordance with Poynting's theorem the fields always carry energy away from the doublet. The phases of the fields E_2+E_3 and H_2 on the other hand, differ by 90° in the neighbourhood of the doublet and the flow of energy due to these are in alternate directions, once towards and again away from the doublet. These are the so-called induction fields with which the electrical engineer has to deal in the case of low frequency. The radiation field which is hardly existent when the oscillation frequency is low gains in prominence with its increase. The modern wireless engineer has to deal with frequencies which might be as high as 100 megacycles/sec. The most striking difference between the induction field and the radiation field is that while the component fields electric and magnetic of the former like the fields due to static charges or steady currents are intimately associated with the conductors carrying the charge or the current those of the latter are not so associated. The induction field will cease to exist the moment the dipole ceases to exist; but not so the radiation field. This field will exist independently of the doublet which gave birth to it. The oscillating doublet may vanish altogether but the radiation field generated by it will pursue its course with the velocity of light, its strength diminishing as it spreads over ever increasing area. We might call the energy of the radiation field the disembodied spirit of the oscillating dipole destined to move in space through eternity. It was the genius of Maxwell[3] which foresaw this about 70 years ago, and it was the genius of Hertz[4] which demonstrated it a quarter of a century later.

Now it can be asked how Hertz's formula which gives the intensity of the radiation field for the case of an electric doublet oscillating in free space can help us in obtaining the value of the field strength for radiation from a transmitting aerial planted on the surface of the earth? Fig. 1 illustrates how this can be achieved. An electric charge Q placed near the surface of an infinite conducting plane produces an image Q'

and the two together produces a field [fig. 1 (*b*)] which, as far as the top half of the field is concerned is similar in every respect to the field produced by a doublet [fig. 1 (*a*)]. Now since the vertical earthed conductor [fig. 3 (*c*)] carrying high frequency alternating current is equivalent to the top half of the vibrating electric doublet we arrive at the very important law that the field due to it at any point on the surface of the conducting plane or above it is the same as the fields—electric and magnetic—in the top half of the field surrounding the oscillating doublet. If, therefore, the earth is taken to be a perfect conductor, and the air above it a perfect insulator and if further the curvature of the surface of the earth be neglected then the formula derived by Hertz about 40 years ago can be used for calculating the field strength due to radiation from a transmitting aerial. It is satisfactory to note that measurements carried out recently

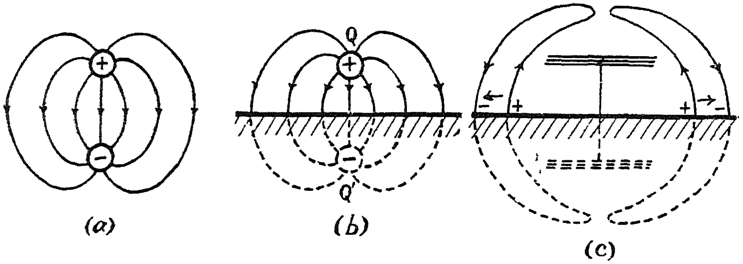

FIG. 1. Illustrating how the electric field due to the earthed aerial (*c*) can be regarded as equivalent to the top half of the field due to an oscillating doublet. In (*c*) a later stage of development is shown. The radiation field in the form of semi-loops has completely detached itself from the conductor. The field is self-sustained by virtue of its motion in the direction of the arrow. In the absence of any motion, an electrostatic field the ends of the lines of force of which terminate on the same conductor, as in (*c*), cannot be so sustained and collapses immediately.

at Cambridge[5] on the five components of the field close to a transmitting aerial gave results which agree closely with Hertz's analysis[2] justifying the time honoured method of regarding the field produced by an earthed transmitting aerial as the upper half of that due to an oscillating electric doublet. The formula of Hertz has since been elaborated by Zenneck[6], Sommerfeld[7] and others[8] by taking into account the finite conductivity and the finite dielectric constant of the earth. These formulas are of great importance in understanding the mode of propagation of radio waves over short distances such as in the case of broadcast transmitter in a city where the difference in the electrical property of the soil in different directions from the transmitter adds to the complexity of the propagation produced by the presence of built up areas of different densities. Waves might attenuate more rapidly in one direction than in other and may not follow the simple inverse-distance law according to Hertz's formula. Surveys of radio field strength round a transmitter measuring the rates of attenuation in different directions are necessary to calculate on the one hand the electrical properties of the soil and obtain on the other hand indications as to the most suitable site for a broadcast transmitter. Such surveys in India have been made for the city of Calcutta (fig. 2) and of Dacca by Rakshit [9] and by Khastgir and Choudhury [10].

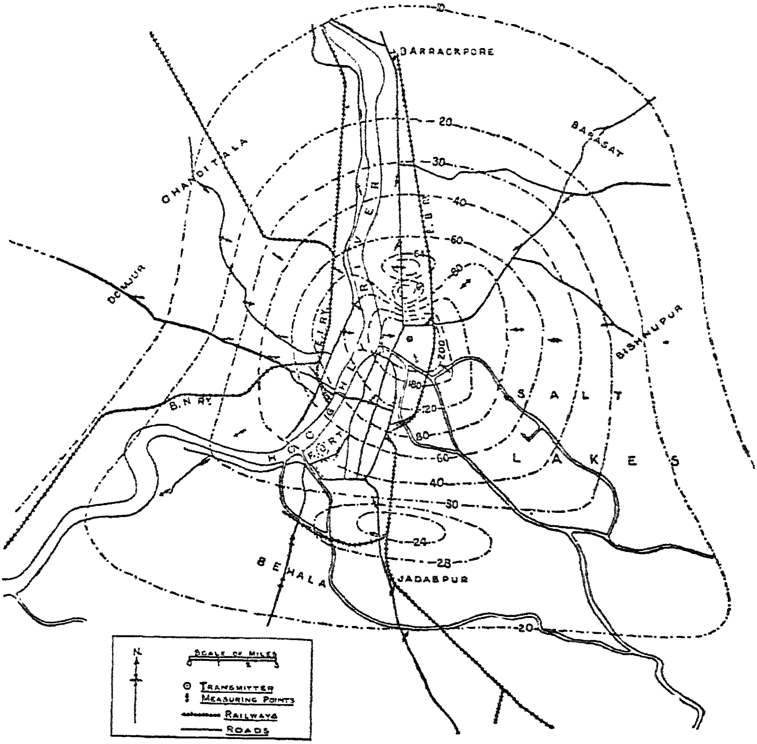

FIG. 2. Radio field strength contour map of the city of Calcutta.

The formulas of Hertz, Zenneck or Sommerfeld being only applicable to the case of flat earth, attempts were made to deduce formulas for the field strength taking into account the curvature of the surface of the earth. The radiotelegraphist presented the problem to the mathematician in an idealized form. An oscillating doublet is situated at any point on the surface of an isolated conducting sphere 6370 km. in radius immersed in a homogeneous non-conducting medium of dielectric constant unity. It is required to determine the strength of the field at any other point on the surface of the sphere produced by the doublet. Notwithstanding its physical simplicity the problem presents many mathematical difficulties and its solution has been obtained only in recent years through the efforts of mathematicians and physicists like MacDonald[11], Rayleigh[12], Poincaré[13], Love[14], van der Pol[15], Watson[16], and others[17]. The values of the field strength calculated from the diffraction formula developed by these authors, however, were found to be wholly inadequate to explain the observed values of field strength. For the case of long distance and for short waves, the observed values of the field strength could be many hundred million times greater than the calculated values.

That this must be so can easily be seen from a comparison of diffraction effect observed in the case of light. The size of the earth bears the same proportion to the length of the radio waves (say 1000 m.) as the size of a sphere ·6 cm. diameter to the length of light waves. Simple experiment shows that the intensity of the light received at a point on the surface of the sphere weakens extremely rapidly as one enters the geometrical shadow and no light is received at points situated on the hemisphere opposite to that on which the emitting point is situated.

It should be mentioned here that in connection with the diffraction theory an erroneous idea was held in some quarters until quite recently. It was thought that the conducting surface of the earth would, by the so-called 'surface-concentration' of energy of the field, be able to guide the waves along it without large attenuation in much the same manner as a pair of wires constituting a Lecher system guide the electric waves along their lengths[18]. In drawing this analogy an important point is overlooked. The surface concentration of energy in the case of the latter is many million times more than in the case of the former. (In the case of propagation along a plane surface only $1{\cdot}5\times10^{-7}$ of the entire field energy is contained within distance of 1 cm. from the surface at a distance of only 100 km. from the transmitter. In the case of a Lecher system of wires, say ·2 cm. diameter and 20 cm. apart fully ·45 of the entire field energy is present within a distance of 1 cm. from the wires). Since near the surface of a good conductor the electric lines of force are normal to the surface (or, rather, slightly tilted forward to supply the energy lost in the conductor) and, since the flow of energy takes place at right angles to the lines of force, it follows that in the case of the Lecher wires a substantial portion of the field energy will be guided by the wires and will flow along the space between the wires even if these are not laid straight but are bent as shown by the dotted lines in fig. 3 (*a*). In the case of a curved plane [dotted line, fig. 3 (*b*)] however, the bulk of the energy cannot be thus guided along the surface.

All these facts led physicists and mathematicians to look for factors other than diffraction intervening in the mode of propagation along the surface of the earth.

From the very early days, since Marconi's successful trans-Atlantic experiments, suggestions have been made from time to time that the atmosphere of the earth might play an important part in deflecting the wireless waves round its curved surface. In 1902, A. E. Kennelly[19] and O. Heaviside[20] almost simultaneously suggested that the upper atmosphere rendered conducting by the ionising action of sunlight might cause such deflection and force the waves to follow the curvature of the earth. Though direct evidence of the existence of this conducting layer was wanting and the nature of its influence on the propagation of wireless waves was ill understood, yet this so-called Kennelly-Heaviside layer gradually became an indispensable element in explaining the mechanism of radio wave propagation along the surface of the earth. As a consequence, the case of wave propagation in the space between two concentric conducting spheres was considered by the mathematicians. The analysis of the idealized case in which the resistivity of the shell was assumed to change suddenly at the boundaries was undertaken by Watson[21] at the suggestion of van der Pol. The calculated fields were again found to be at variance with the observed ones, though of course, not to such extent as in the case of pure diffraction formula. It was clear that the idealized boundary condition assumed for facilitating analysis had to be abandoned and actual boundary conditions introduced. But the introduction of these, about which so little is known, rendered the problem far too complex to be amenable to mathematical analysis.

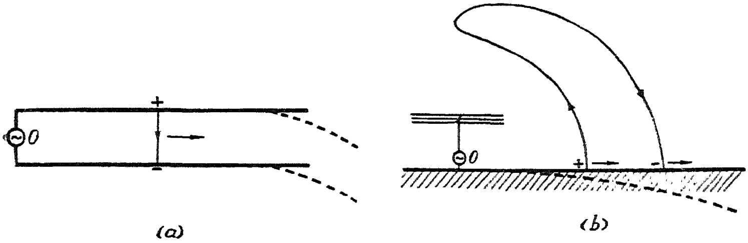

FIG. 3. Illustrating the difference in the mode of propagation of electric waves along a Lecher system (*a*) and along a plane conducting surface (*b*). The Lecher system, on account of surface concentration of energy, can guide the wave along its length even when it is bent (dotted lines). Such guiding is not possible in the case of the plane surface.

Attempts of Radiotelegraphists to derive semi-empirical Formula.

In the meantime, while mathematicians and theoretical physicists were busy solving idealized problems such as those mentioned just now, the practical radiotelegraphist to whom a rule connecting the field strength with distance, wavelength, height of the transmitting antenna, etc. was of vital importance, had been carrying on extensive measurements on the signal strength at near and distant points from the transmitter. Ships equipped with field strength measuring instruments made long voyages solely for the purpose of obtaining some sort of a relation between the various variables involved. As a result of intensive work carried over a number of years the radiotelegraphist was presented with the well-known theoretical-cum-empirical formula known as the Austin-Cohen formula [22] the modern modified form of which is

$$F = \left[\cdot 377 \times 10^{6} \frac{h\mathrm{I}}{\lambda} \cdot \frac{1}{r} \right] \epsilon^{-\frac{\cdot 0014 r}{\lambda \cdot 6}} \cdot \sqrt{\frac{\theta}{\sin \theta}} \cdot$$

(F field strength in micro-volts per metre, h effective aerial height, I aerial current, λ wavelength and r distance from the transmitter. I is in ampere and all lengths are in kilometres. θ is the angle subtended at the centre of the earth by the transmission path in radians.)

The formula has no theoretical justification inasmuch as it is nothing but the expression for the field strength for propagation along a plane conducting surface (the factor within the square brackets) multiplied by an exponential or attenuation term which is supposed to take care of the losses due to absorption and to diffraction (the factor $\sqrt{\frac{\theta}{\sin \theta}}$ was put in later). In spite of its theoretical weakness this formula for a long time remained the most respected attenuation formula and was widely used by radiotelegraphists for estimating the most useful wavelength for purposes of communication between two distant lands. Recently a formula suggested by Watson and Eckersley in which the factor within the square bracket is replaced by the expression for propagation in a spherical shell bounded by conducting concentric spheres has been found to give much better agreement with observed field strength. Taking the case of the Austin-Cohen formula, if we combine with it conditions regarding the transmitting aerial such as the maximum power available or the maximum voltage which the transmitting aerial can withstand we obtain a very simple and useful rule for estimating the optimum wavelength for carrying communication between two distant points. It is found that with certain medium wavelengths, the best working wavelength is about $\frac{1}{500}$th of the distance which separates the two stations.

For instance, the distance between England and India being 10,000 km. the best working wavelength is 20 km. If wavelength much longer or much shorter is used with the same aerial and same input power the signal strength will fall. The wavelength actually employed by Rugby is 18·8 km. These facts are depicted in curve I of fig. 4.

It is seen from the curve that wavelengths below 1,000 metres are of little or no use for long range communication and that in order to cover long distance one must use long waves with attendant huge aerials. The various radio communication stations therefore in their eagerness to reach long distances entered into, what has been humorously called, coil winding competition increasing their wavelengths and erecting aerials of huge dimensions. St. Assise has 16 masts each 250 m. high, Nauen 8 masts each 207 m. high, Rugby 12 masts each 248 m. high. The corresponding wavelengths for trans-continental communication are 20 km., 12·8 km., and 18·8 km. So great was the faith of wireless engineers in long waves that even at the beginning of the last decade no engineer who cared for his professional reputation would have asserted that long distance communication could be carried on with wavelength less than 1,000 metres. But strange to say this is exactly what has happened. Towards the beginning of the last decade, just at the time when it seemed that after twenty years of research and labour the wireless telegraphist had at his disposal the right formulas for computing field strength at distant points, it was discovered that England could actually reach India on wavelengths much less than 1,000 metres in flagrant disobedience to the Austin-Cohen formula. For example, the Empire broadcasting which we enjoy every day is carried on with wavelength of only 19·82 m. and with input barely one-twentieth of that employed by Rugby. This remarkable distance reaching property of the short-wave which cannot be foreseen from the Austin-Cohen or the Watson-Eckersley formula, came as a surprise, one might say, almost as a shock to the professional radiotelegraphist. The relation between wavelength and field strength for wavelengths less than 100 m. which is not covered by the Austin-Cohen formula is depicted very roughly in curve II, fig. 4.

It is evident that the mode of propagation of the short-wave is entirely different from that by consideration of which formulas of Austin-Cohen or the Watson-Eckersley type are deduced. I shall tell you briefly how the remarkable properties of the short-waves came to be discovered.

Advent of short-wave.

With end of the world war in 1919 began the era of thermionic valve and wireless broadcasting. The ease with which high frequency electric oscillations could be generated and detected, produced a large number of amateur wireless experimenters who, not satisfied with merely listening to the broadcast programmes, were eager to possess experimental transmitters of their own. They had to be allotted certain bands of wavelengths with which they could play without interfering with serious wireless communication. The long waves over 3,000 m. were reserved for trans-continental communication, the medium waves between 3,000 and 200 m. were for marine communication and for broadcasting. The amateurs were therefore allotted the wave band below 200 m. which was useless for serious work and with which they could experiment with impunity. The amateurs in blissful ignorance of the Austin-Cohen formula sought to increase the range of their transmission by lowering the wavelengths and soon began to give amazing reports of carrying two-way communication between lands separated by continents and seas. At first the reports were received with considerable scepticism and the results were put down as freak transmissions. But soon evidence began to accumulate and technicians were forced to admit that here was something really new in the pheno-

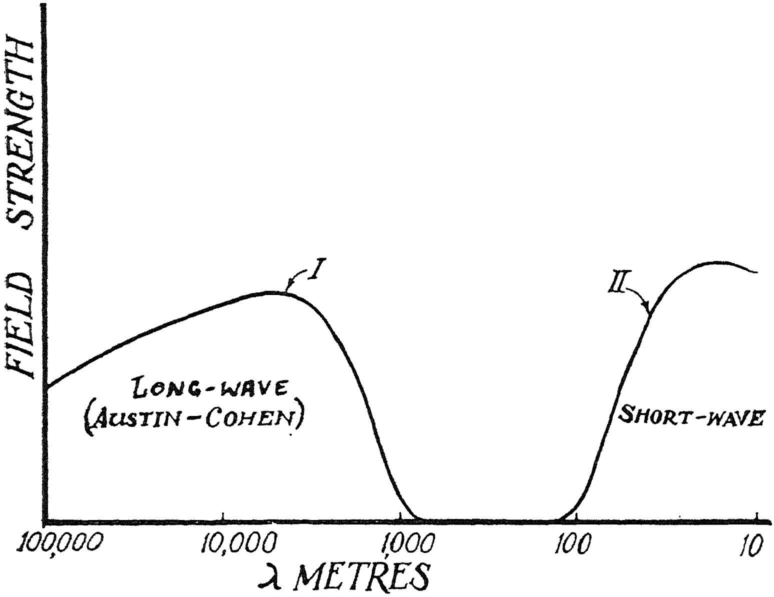

FIG. 4. Illustrating variation of signal strength with wavelength at a distance of 4,000 km. from the transmitter. The ability of short-waves to produce strong signals at such distances (curve II) was discovered accidentally by amateurs. Curve II (experimental) is not deducible from Austin-Cohen formula.

menon of wireless transmission. Large commercial stations like those of Telefunken company's at Nauen, Germany began experimenting seriously by carrying test transmissions on different wavelengths at different hours of day and night with distant lands. The experiments soon dispelled all doubts as to the wonderful range of short-waves on power which could be even as low as $\frac{1}{1000}$th of that employed by long wave commercial trans-continental stations. Various novel properties such as marked dependence of signal strength on the hour of the day or night, the phenomena of 'fading' and of 'skipping' were also discovered. It was obvious that the mode of propagation of short-waves was quite different from that of long waves. The hypothesis of propagation in the space between the surface of the earth and an upper conducting layer on the basis of which formulas of Austin-Cohen or Watson-Eckersley type were based was wholly inadequate to explain the extremely low attenuation of the short-waves. It was necessary to look more closely into the mode of propagation of the waves in the upper atmosphere with special reference to the part played by the ionised Kennelly-Heaviside layer.

Eccles-Larmor Theory.

The fundamental ideas underlying the nature of the influence of the electrons and ions of an ionised atmosphere on the propagation of radio waves were laid by Eccles[23] in 1912. Some essential details which were lacking and for which the idea remained undeveloped for some years were supplied by Larmor[24] in 1924. The so-called Eccles-Larmor theory is now regarded as the basic theory of radio wave propagation in the ionosphere.

The essential of the theory is that the presence of electrons and ions in an ionised gas causes a reduction of its effective dielectric constant and a consequent increase of phase velocity of radio waves passing through it. The nature of these effects is analogous to the nature of similar effects met with in optics in the classical theory of dispersion of metals. The free electrons in the metal reacting to the electric forces developed by a passing light wave increases its phase velocity to a value which can be greater than that of light in free space. There is, however, one important difference between the two. Collision between electrons and ions which plays an important part in the optical theory of dispersion causing absorption is practically absent in the case of propagation of waves through the ionosphere. The electrons in the ionosphere have long mean free paths on account of low pressure and their collisions with neighbouring atoms and molecules being few and far between they can execute vibration in response to the electric forces of the radio waves without much frictional loss. The waves can thus be propagated over long distances in the ionosphere without appreciable attenuation. When a ray of radio waves coming up from the earth meets the under-surface of the ionosphere it follows one of the following three alternative courses depending upon the angle of incidence and the frequency of the former, and the electronic density and its gradient of the latter. Firstly, the ray may pierce right through the ionosphere. [Ray marked I, fig. 6.] The radio wave in this case is lost to the earth and is not of much concern to the radiotelegraphist. Secondly, it may take a sharp turn near the point of incidence without much penetration into the ionosphere and return to the earth as if it were reflected by the ionospheric boundary. This is the case of long wave propagation depicted in fig. 5. Here the waves are confined in the shell between the earth and the ionosphere and Austin-Cohen or Watson-Eckersley formula is applicable. Thirdly, it may penetrate deep into the ionosphere, its path gradually bending on account of the gradual increase of phase velocity of the wave front from bottom to top and may make a long part of its journey in the ionosphere itself following approximately the curvature of the earth's surface. This is the case of short-wave propagation depicted in fig. 6 rays marked III. The attenuation here is low and it is evident the Austin-Cohen or Watson-Eckersley formula developed for the type of propagation shown in fig. 5 is wholly inapplicable. (There may of course be types of propagation intermediate between the three classified above. Recent observation by Hollingworth[25] on the angle of incidence of the rays coming down from the ionosphere from a very distant (2,500 km.) short-wave station shows that there are a certain finite number of possible paths for the ray which have a considerable degree of permanence over others.)

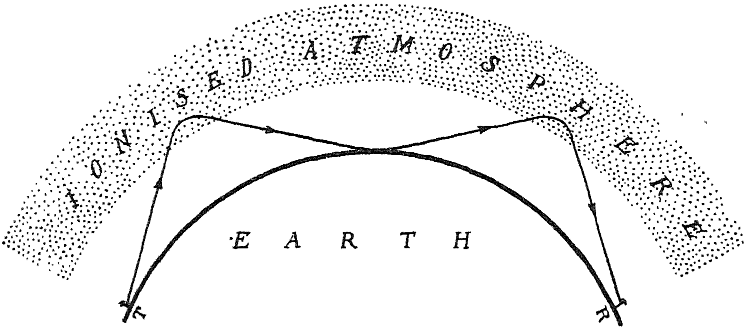

FIG. 5. Illustrating the mode of propagation of long waves. The ray is confined in the shell between the earth and the ionised upper atmosphere. There is little penetration inside the ionosphere.

The simple theory of Eccles and Larmor outlined above has recently been elaborated by Appleton[26], Hartree[27] and others.

by taking into consideration the effect of the earth's magnetic field on the motion of the electrons and ions. The effect is to cause the ionised region to behave like a doubly refracting medium. Splitting up of echoes of radio waves returned from the ionised layer [28] and observation on the difference in the nature of the polarization of the down-coming waves in northern and in southern hemispheres [29] testify to the correctness of this magneto-ionic theory.

During recent years the reduction of the dielectric constant of an ionised gas to value less than unity [30] as well as the effect of the magnetic field on same have been the subject of much experimental investigation.[31] But unfortunately the experimental conditions in most of these investigations are such that the effect of the conductivity of the ionised gas in the space between the plates of the experimental condenser tends to mask the true effect. In spite of this and other difficulties many authors have been able to detect the reduction of the dielectric constant as well as the resonance effect in the presence of the magnetic field in ionised gas. The origin of some of the discrepancies in the results has been traced and discussed by B. C. Sil [32] and by S. S. Banerjee.[33]

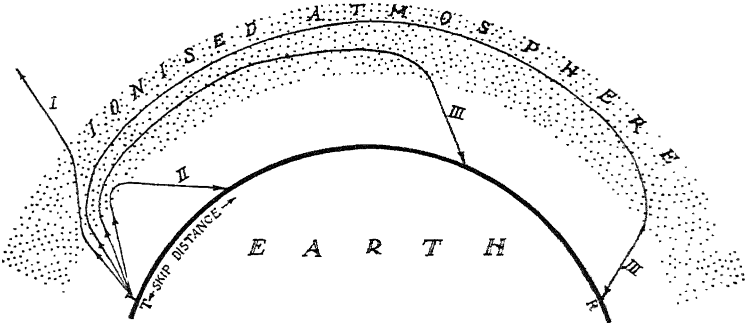

FIG. 6. Illustrating the mode of propagation of short-waves. The ray penetrates deep into the ionosphere and the path of the ray lies almost wholly in the ionosphere itself.

An interesting extension of the Eccles-Larmor theory to the case of the propagation of light through a cloud of free electrons has recently been discussed by Mitra and Rakshit.[34] It has been shown that the space charge set up near the surface of a hot metal should produce detectable bending in a beam of light passing close and parallel to the surface of the metal.

The Eccles-Larmor theory and the newly discovered properties of short-wave propagation have given fresh impetus to experimental investigation on the constitution and on the physical properties of the ionised upper atmosphere. In the next section I shall attempt a brief survey of the present state of our knowledge of and recent work on the ionosphere.

The Ionosphere.

The existence of a conducting upper atmosphere was envisaged long before the suggestion of Kennelly and of Heaviside in 1902. The intensity of the earth's magnetic field undergoes daily variation the origin of which was for a long time a puzzle to the magnetician. In 1878, Balfour Stewart [35] postulated the existence of conducting strata in upper atmosphere and suggested that daily variation of magnetic intensity could be explained as due to the field produced by electricity induced in these strata as they moved accross the steady magnetic field of the earth. This theory known as the 'dynamo theory' was further developed by Schuster [36] four years later. It might be said that Kennelly and Heaviside re-discovered this conducting property of the upper atmosphere in 1902 about twenty years later for explaining the phenomenon of propagation of radio waves along the surface of the earth. It is now recognized that the Stewart-Schuster conducting layer producing variation of earth's magnetic field is substantially the same as Kennelly-Heaviside conducting layer carrying electromagnetic waves. This fact shows how lack of co-ordination amongst scientific workers in different branches retards the progress of knowledge.

The conducting upper atmosphere, though postulated by Kennelly and Heaviside in 1902, lacked direct evidence as to its existence till 1924. Agreement of quantitative measurements on long wave field strength with Watson-Eckersley formula, the many peculiar features of short-wave propagation discovered since 1921 all pointed towards the existence of such a layer. But the evidence of these was rather of an indirect nature. The first direct evidence came in 1925 when Appleton and Barnett [37] by comparing the intensities of fading of signals received simultaneously on a loop and on a vertical aerial proved the existence of indirect or sky waves coming down after reflection from the Heaviside layer. Immediately afterwards Smith-Rose and Barfield [38] detected the presence of down-coming waves by employing direction-finding apparatus of their own design. These experiments not only gave direct evidence of the reflecting layer but also disclosed some of its properties, e.g. its height, reflecting power, etc. But perhaps the most striking evidence was that furnished by experiments of Breit and Tuve.[39] These authors showed that wave packets of small duration sent out from the transmitter produced two (sometimes more) impulses instead of one in a receiver placed a few kilometres from the transmitter. The obvious conclusion was that the impulse coming first was due to the direct wave travelling along the ground and the others coming later were due to indirect waves or echoes once or twice reflected from the ionosphere. This method —the so-called pulse method—developed by various investigators has now become the most powerful method of sounding the ionosphere. (See fig. 7.) In fact, the use of the radio waves is the only means now at our disposal for studying such high regions as hundreds of kilometres above earth's surface. The famous Piccard balloon ascended up to 16 km., the recent Soviet balloon up to 19 km. The sounding balloons sent by the meteorologists may reach up to 40 km. But the radio

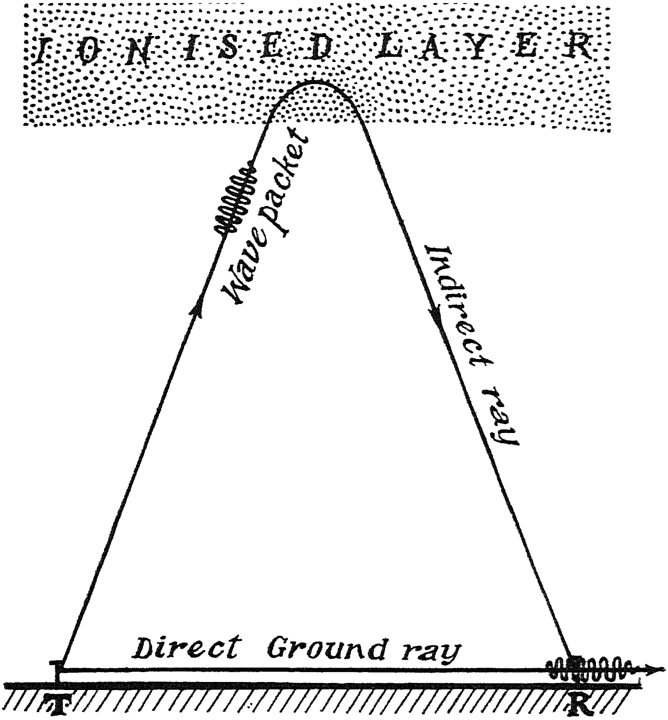

Fig. 7. Illustrating the pulse method of sounding the ionosphere. Trains of wave packets or pulses are shot upwards from the transmitter. (Typical values: 200 packets per sec., length of each packet 50 km., duration of emission of same $\frac{1}{6000}$th sec. The length of the packet is not drawn to scale in the figure.) These returned by the ionosphere reach the receiver a few milli-seconds after the corresponding packets travelling directly along the ground. If the wave frequency is high they pierce through the ionosphere and fail to return. The distance between the transmitter and the receiver formerly used to be several kilometres. They need not be so separated now. The transmitting aerial can be used for receiving the echoes at absolutely normal incidence[39a].

waves only can ascend beyond these heights and, when they come down 'reflected' by the ionosphere, they bring with them indelible messages regarding its physical condition which are quite as useful as those recorded by instruments carried by sounding balloons. Photographs of typical echo patterns as seen on the screen of the cathode ray oscillograph connected to the recording system are given in fig. 8.

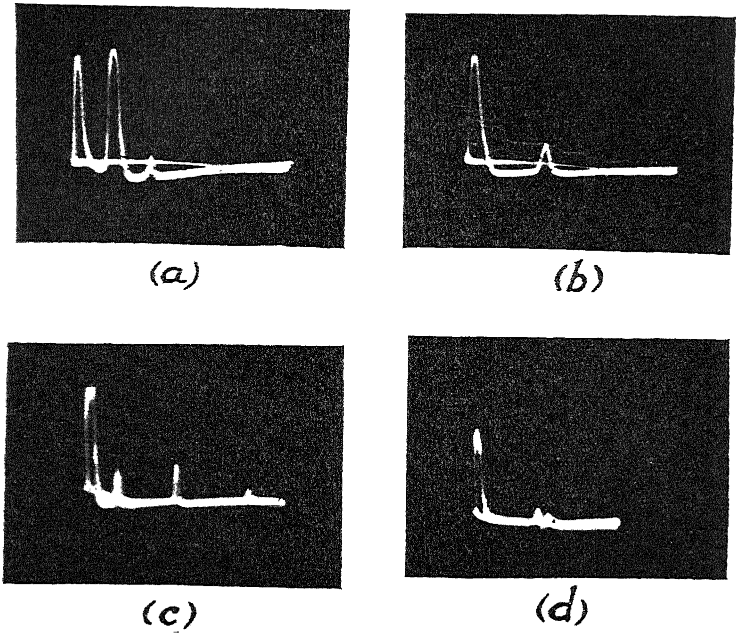

Fig. 8. Illustrating typical echo patterns as seen on the screen of the cathode ray oscillograph of the receiving and recording system. The signal first from the left is due to the direct or the ground ray. Others following are the echoes. In (*a*) the second and third signals are echoes once and twice reflected from the *E* layer. Note the abnormal strength of the first echo. In (*b*) the single echo is from the *F* layer. In (*c*) the second signal is echo from the *E* layer and the third and the fourth ones are once and twice reflected echoes from the *F* layer. In (*d*) magnetic splitting of echo from *F* layer is shown. (Calcutta.)

In their original investigations Breit and Tuve, after the true American fashion, used large power transmitters—7 to 10 k.w.—such as are not readily available in ordinary laboratories. It has subsequently been found however that with the right type of aerial quite small power suffices to show the existence of echoes of signals sent up from the transmitter. For instance, the aerial power in the Science College at Calcutta seldom exceeds 20 watts.

I shall now make a brief survey of the present state of our knowledge about the properties and physical conditions of the ionosphere.

Stratification and Heights of the different Layers of the Ionosphere.

Observations and measurements on the ionosphere carried by the pulse retardation method of Breit and Tuve soon disclosed the fact that the single ionised layer hypothesis of Kennelly-Heaviside was insufficient to explain all the observed facts. In 1927, Appleton [40] announced the discovery of another ionised layer much higher than the Kennelly-Heaviside layer and much richer in ionisation. Observations in India by Mitra and Rakshit [41] confirmed this hypothesis. It was shown that the two layers were quite distinct from one another and were not merely different locations of the same layer which has moved continuously from one height to another. The equivalent heights of the two layers as measured at Calcutta are 90 km. for the lower Kennely-Heaviside or *E* layer and 230 km. for the upper Appleton or *F* layer. The heights are liable to variation with the hour of the day and the season of the year and the values given above are only average ones as found at Calcutta. Further, the heights are not true heights. In calculating the height from the time retardation of the echoes it is assumed that the group of waves has travelled throughout its journey with the velocity of light whereas in reality the very mechanism of the return of the waves entails the reduction of the group-velocity to zero before the velocity is reversed. Fig. 9 gives the midday values of the equivalent heights of the two layers throughout the polar year 1932-33 as measured at Calcutta. Quite recently American [42] and British observers [43] have almost simultaneously reported indications of other regions of maximum ionisation close to the two clearly distinguishable *E* and *F* regions. One of the maxima *E′* is a little above *E* and the other *F′* a little below *F*. These maxima are neither so pronounced as the *E* and the *F* ones nor are so persistent. They are formed only in certain parts of the year and even then they are distinguishable only at certain hours of the day. American observers report having noticed them in winter only for a few hours round noon while English observers in early morning and late evening and sometimes throughout many winter days. We have also been able to detect this fine structure of the ionosphere from time to time at Calcutta and we are making a more systematic study of it this winter. The heights of the successive layers are roughly 90, 120, 180, and 250 km. for *E*, *E′*, *F′*, and *F*.

Ionic density, density gradient, nature of charged particles.

An elegant method has recently been developed by Appleton[44] for measuring the ionic densities of the different layers of the ionosphere. The frequency (of the wave) of the train of exploring wave-packets directed upwards is gradually increased till it pierces through a particular layer and fails to return from the same. The maximum ionic density of the layer which is thus pierced is proportional to the square of the critical frequency. Measurement carried by this method shows that for ionosphere over Calcutta at noon on summer solstice the densities are (in electrons per c.c.) $7{\cdot}3 \times 10^5$ for E and 20×10^5 for F layer. Corresponding values in England[45] are $3{\cdot}8 \times 10^5$ and 12×10^5. Regarding the ionic densities in the intermediate layers it is obvious that a layer the maximum ionisation of which is less than that of a layer underneath it cannot be detected by sending upwardly directed wave packets of varying frequency. A particular frequency which pierces the lower layer of higher density will obviously pierce any higher layer of lower density. Any layer above F with ionic density lower than F would obviously remain undetected.

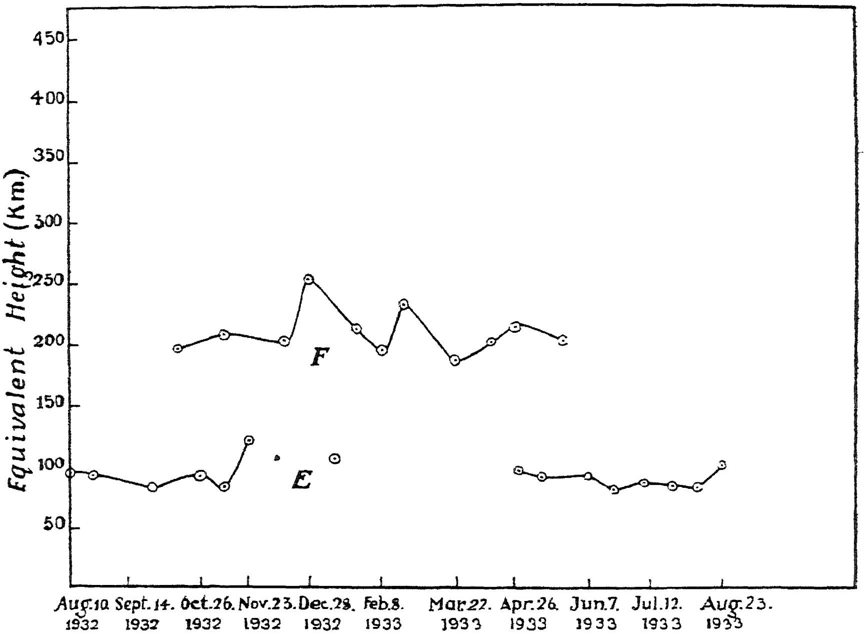

FIG. 9. Midday values of the equivalent heights of the E and F layers throughout the polar year 1932-33. (Calcutta.)

It must be mentioned that the above experiments leave undetermined the nature of the charged particles whether they are electrons or ions. [As far as the propagation of radio waves is concerned n_i ions of mass m_i each can be replaced by n_e 'equivalent electrons' of mass m_e each where $n_e = n_i \frac{m_e}{m_i}$.] Experiments on the nature of polarization of the down-coming echoes in the light of the magneto-ionic theory serve to determine the nature of the particles. Such experiments show that for the *F* layer at least the particles are electrons.[46] It is possible that the ionisation of the *E* layer is also due to electrons. But a preponderance of heavier ions is not improbable. The high ionic density (10^8 to 10^9 ions per c.c.) demanded by the 'dynamo theory' of the variation of the earth's magnetic field can be satisfied if the charged particles are ions of, say, nitrogen or oxygen.[47]

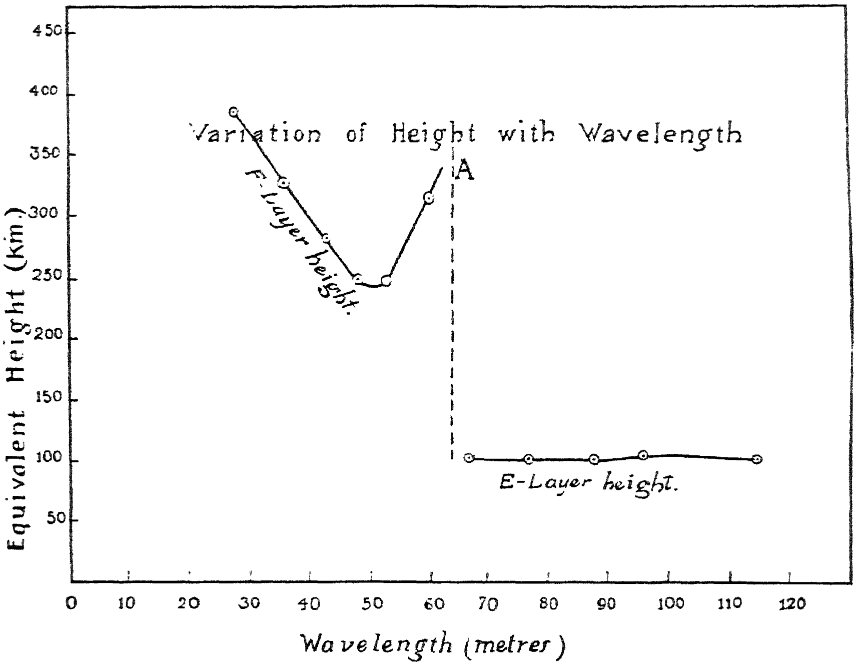

FIG. 10. Illustrating the variation of equivalent heights of the *E* and the *F* layer with change of frequency of the exploring wave packets. The *E*-layer height does not change sensibly. The *F*-layer height decreases with decrease of frequency. Note the abnormal increase of the equivalent *F*-layer height at *A* near the critical penetration frequency of the *E* layer. (Calcutta.)

The density gradient of these layers is difficult to estimate. A rough idea can be made by noting the change in the equivalent height with the change in the frequency of the exploring wave packet. This is depicted in fig. 10 from observations made at Calcutta. It is seen that the height of the *E* layer changes

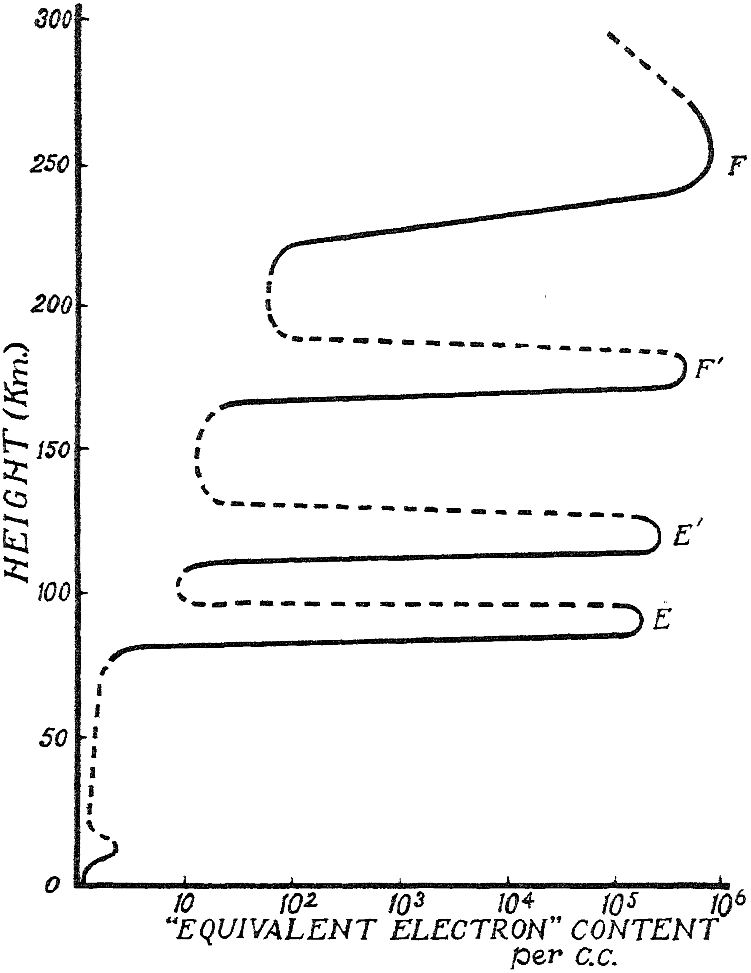

FIG. 11. Rough illustration of the probable variation of 'equivalent electron' density with height from the ground level. The small maximum near 12 km. is supposed to be due to the action of cosmic rays. The strongly ionised regions *E*, *E′*, *F′* and *F* constitute the ionosphere. *E* and *F* are the main divisions. The intermediate layers *E′* and *F′* (of which there are sometimes more) are not always easy to detect.

very little with frequency showing that the density gradient must be steep. [The reason of the apparent increase of the *F*-layer height at the beginning (*A* of fig. 10) of the frequency height curve is interesting.[48] The frequencies round about this point are not far removed from the critical penetration frequency of the lower *E* layer. For these frequencies the group-velocity in the *E* layer being abnormally low the corresponding wave packets are abnormally retarded in passing through the *E* layer and record an apparent increase in height of the *F* layer.] Proofs are also available which show that the upper boundary of this layer has also a steep gradient. The height of the *F* layer, on the other hand, increases with increase of frequency of the exploring wave packets indicating that the higher frequencies have to ascend much higher levels in order to reach the region of critical density where their group-velocity becomes zero. Magnetic splitting [see fig. 8 (*d*)] of the exploring wave packet which occurs mostly in the *F* region also shows that the density of ionisation increases more gradually in the *F* layer than in the *E* layer. Recently, by measuring the time interval between the split components of the echoes Rakshit has been able to make an estimate of the depth of penetration of the wave packets into the *F* region.[49] On a particular occasion it was found that the waves penetrated 50 km. in the *F* region before being turned back.

In fig. 11, I have tried to give a rough picture of the variation of the equivalent electronic density of the atmosphere as one ascends from the ground level. The air near the ground is conducting owing to radio-active matter in the earth and in the air itself, and by cosmic rays.[50] The equivalent electronic density is not more than ·1 per c.c. The density increases for the first few kilometres up to a height of about 12 km. where the action of the cosmic rays is felt greatest. Beyond this the density again falls being 6×10^{-3} per c.c. (200 ions per c.c.) at a height of 16 km. (From observations made in the Piccard balloon ascent.[51] The observational data of the Soviet balloon ascent up to 19 km. are not yet available.) The density does not alter much above this height till we reach the level of the *E* layer. Here the density increases rapidly and attains a value $1{\cdot}8 \times 10^5$ at 90 km. The densities[45] and successive heights of *E′*, *F′* and *F* layers are $2{\cdot}5 \times 10^5$, $3{\cdot}8 \times 10^5$, $6{\cdot}1 \times 10^5$ and 120, 180, 250 km. In the *F* layer the density increases very gradually and the thickness of the layer is much greater than the *E* layer.[52]

In fig. 12, I have attempted to give a more vivid idea of the regions occupied by the ionospheric strata with respect to those occupied by other known strata discovered by spectroscopists and meteorologists. The region from the surface of the earth up to a height of about 12 km. (average) is known as troposphere. This is the region of wind and storm, of thunder and lightning. The temperature here falls regularly as one goes up and the various atmospheric constituents are thoroughly mixed up. Till lately, it was believed that except as a source of 'atmospherics' or 'statics' which interfere with good reception of radio signals, this region was of little importance to the radiotelegraphist. Indeed, by a close study of records of atmospherics Watson Watt[53] has shown that they are not only of thunder-storm origin but that they can even be utilized for locating the centres of origin of such storms. But the troposphere has now gained in importance to the radiotelegraphist for another reason. It is believed that intense electric field in thunder-clouds might be one of the agencies producing cosmic rays and that these latter in their turn can strongly affect the ionisation of the ionosphere (see next section). The whole region above the troposphere where the temperature is sensibly constant with height is usually called by the meteorologists stratosphere. The dividing plane between the two where the well-defined change of the so-called 'lapse-rate' of temperature occurs is known as tropo-

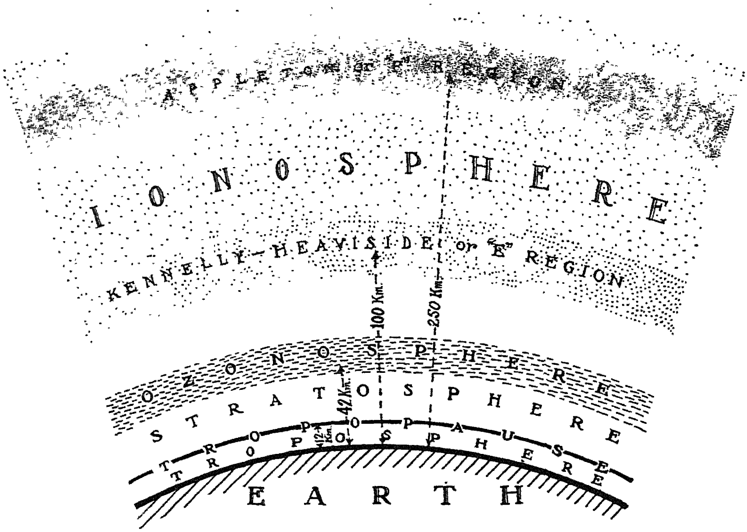

FIG. 12. Illustrating the divisions of the upper atmosphere. The troposphere is the region of wind and storm. The temperature here falls with height. The stratosphere is the region of constant temperature. The dividing surface between the two is the tropopause. The recently added ozonosphere is the region where ozone is formed by the action of sun's rays. The latest addition to these systematic groups of '—spheres' is the ionosphere of which the two main sub-divisions *E* and *F* regions are shown. The intermediate finer structure (fig. 11) is not shown.

pause. It has recently become convenient to admit another region above the troposphere where ozone is formed by the action of the ultra-violet light of the sun. The stratosphere can thus be divided into an inner shell for which we may retain the name stratosphere and an outer shell above 40 km. which we call ozonosphere. The thickness of the ozonosphere is estimated to be 40 to 60 km. (At a height of 50 km. it is estimated that the density of ozone is 2×10^{-4} as compared with 2×10^{-8} at sea level.[54] Mela Ram[55] shows that at a height of 18,000 ft. the absorption limit of the solar spectrum remains unchanged showing that the atmospheric ozone is confined in higher strata.) Above the ozonosphere beginning from a height of about 90 km. we have the various ionised strata collectively known as ionosphere which is of extreme importance to the radiotelegraphist. Neglecting the fine structure the ionosphere is divided into two clearly distinguishable regions, the lower the classical Kennelly-Heaviside or the *E* region and the upper the recently discovered Appleton or the *F* region. The respective average heights of the regions of maximum density of these regions are 100 km. and 250 km. The density gradient is much steeper in *E* layer than in *F* layer.

Variation of the Ionisation Content.

The ion content or rather the equivalent electron content of the various strata of the ionosphere is not constant but undergoes fluctuation. It varies markedly with the hour of the day or night and with the season of the year. (For instance, on a summer day, the midday and midnight values of the electron density at Calcutta are $7{\cdot}3 \times 10^5$ and $1{\cdot}2 \times 10^5$ for *E* layer and 20×10^5 and 3×10^5 for *F* layer. Again, the midday values for summer and winter are $3{\cdot}75 \times 10^5$, 12×10^5, $1{\cdot}2 \times 10^5$, and $3{\cdot}8 \times 10^5$ respectively for England.) The hourly variation on a summer day at Calcutta is given in curve II, fig. 13, from observations made by Syam[55a]. In addition to these daily and yearly variations which are closely connected with the diurnal and annual motions of the sun, there are indications of long period variation connected with the 11-year sun-spot cycle.[56] At present we are passing through a period of minimum activity and it is possible that in about 5 or 6 years' time ionisation content will increase much beyond the average values recorded now.

To these marked periodic variations one can add a less marked daily increase of ionic density which occurs a few hours after sunset and is known as 'evening concentration'. This has been recorded by many workers including ourselves.[57, 58]

Besides these periodic variations one often notices sudden outbursts of variation which might last for hours. Again, the strength of the echo as recorded by the strength of the indirect signal on the cathode ray oscillograph screen is seldom steady. During day time its fluctuation is small, but during the sunrise and the sunset periods as well as during the period of 'evening increase' the echo-strength undergoes violent fluctuations the period of which might be from a fraction of a second to several seconds. Actual measurements of field strength of echoes by Rakshit[59] show that the strength sometimes increases abnormally much beyond the value calculated on the assumption of a perfectly reflecting ionosphere [see, for instance, fig. 8 (*a*)].

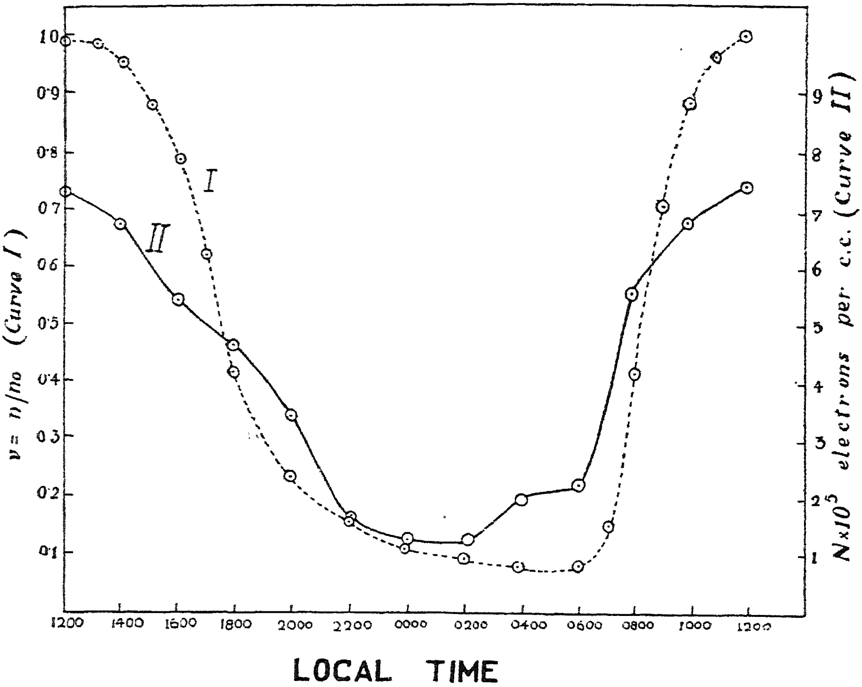

FIG. 13. Illustrating hourly variation of ionisation content. Curve I is calculated after Chapman. Curve II is from actual observations. Both curves are for summer solstice, Calcutta.

Mention should be made of one significant fact which has been observed by us as well as by others that such abnormal fluctuations are more frequent and more marked during the monsoon months when the electrical condition of the lower atmosphere is greatly disturbed.[60] The origin of these irregular variations indicating violent agitation in the electronic density and density gradient of the ionosphere is still under investigation. At night the main ionising agency the sunlight is withdrawn. And at such heights the wind and the general commotion of air which are the peculiar features of the lower atmosphere—the troposphere—are entirely absent. The existence of the ionospheric fluctuations at such heights and at such hours naturally indicates that there are other agencies, besides sun's rays, at work causing ionisation of the upper atmosphere.

Agencies responsible for Ionisation.

From the diurnal and seasonal variation of the height and the ion content it can safely be inferred that the ultra-violet light of the sun which produces ozone in the upper atmosphere is also the principal cause of ionisation in the ionosphere. Assuming a homogeneous atmosphere Chapman[61] has indicated the method of calculating the ion content at any hour of the day or night at any latitude, in any season. Curve I in fig. 13 shows after Chapman the hourly variation of ion content in summer solstice for Calcutta. The observed values are shown in curve II of the same figure. It is seen that the agreement is fairly good.

The ultra-violet radiation from the sun however does not rule out the possibility of other agencies playing important part in the production and maintenance of the ionisation. Of such other agencies mention might be made of corpuscles (charged or uncharged) and electrons shot off from the sun, penetrating radiation like cosmic rays of either extra-terrestrial or terrestrial origin and meteoric showers.

Of corpuscles and electrons shot off from the sun the possibility of the emission of such particles by selective radiation pressure has been discussed by Milne[62], and it is now recognized that such particles do enter the atmosphere of the earth. The appearance of aurora borealis and the incidence of magnetic storms are generally associated with the arrival of streams of such particles. The particles since they are charged would be concentrated mostly in the higher magnetic latitudes. They have to be endowed with extremely high velocity if they are to reach the lower latitudes by overcoming the earth's magnetic field. Brüche[63] calculates that for particles of electronic mass the velocity has to be above that corresponding to 5×10^9 volts in order that they may reach latitudes lower than 50°. Such high-speed particles as will reach the lower latitudes will, on account of their high penetrating power, ionise only the denser atmosphere much below the E layer. Any variation of ionisation produced by the arrival of charged corpuscles or electrons from the sun will therefore be more marked in the higher magnetic latitudes than in the lower. This is precisely what has been observed recently by Appleton, Naismith, and Builder[64] in their wireless observations at Tromso, Norway. The correlation between magnetic storms and abnormal ionisation which is poor in lower latitude[65] is very marked at such high latitudes.

The concentration of charged particles in the atmosphere over the polar caps associated with frequent outbursts of magnetic activity is probably responsible for the difficulty in maintaining wireless communication over these regions. It is of course possible for particles following a curved path to reach the lower magnetic latitudes. Such particles arriving in the upper atmosphere during the dark hours may cause the 'evening concentration' of ionisation so frequently observed.[66]

As regards ionisation produced by cosmic rays the nature and origin of these latter are still matters of controversy. In any case whether they are fast moving electrons (with a velocity approaching that of light), or highly concentrated energy quanta (ultra-gamma rays) coming from the sun or the stars it is improbable that owing to their tremendous energy they would ionise the thin air of the *F* or the *E* regions. The region of maximum ionisation produced by these rays must be much lower than the *E*-layer height. (For instance, observation in the Piccard balloon ascent[67] shows that at a height of 16 km. the ionisation by cosmic rays already became weaker.)

A terrestrial origin of these rays has recently been suggested by Wilson.[68] A particle of radio-active origin finding its way into the strong field of an electrified cloud might acquire a high velocity and produce cosmic rays. The sense of the field is such that these particles are directed upwards. Recent observations by Schonland and Viljoen[69] give strong support to the theory. The opinion is gaining ground that such radiation originating in a thunder cloud can strongly affect the ionisation of the ionosphere.[70] Herein probably lies the explanation of the increased disturbance of the ionosphere indicated by irregular and abnormal variation of echo strength so frequently observed during the monsoon periods in India.

Regarding meteors which, gravitating towards the earth, bombard the upper atmosphere calculation by Skellett[71] shows that their ionising effect is far from negligible. Measurements made at Calcutta on the ionisation content of *E* layer during the last Leonid meteor shower (on Nov. 13, 14, and 17) showed that there was a marked increase in the ionisation between midnight and early hours of the morning which is the time of the most frequent arrival of the meteors. In fact such high ionic density at such hours was never recorded in the fortnightly observations made by us during the polar year 1932-33. Goodall and Schafer making observations on the heights of the ionised layers during the Leonid shower of 1931 failed, however, to derive any definite co-relation[72].

Origin of Ionospheric Stratification.

The origin of the two distinct regions of maximum ionisation *E* and *F* as well as that of the finer divisions of the ionosphere is still uncertain. The theory that the two main regions derived their ionisation from two different agencies has, at present, not many supporters. (See, for instance, discussion at the Royal Society on Ionosphere on June 21, 1933[73] and contribution thereto by Watson Watt and others.) Such a theory was put forward some time ago by Chapman.[74, 75] He suggested that one of the two main regions derived its ionisation from the ultra-violet light and the other from corpuscles shot off from the sun. The corpuscles were assumed to be electrically neutral so that the earth's magnetic field had no effect on them, and they could arrive at the earth pursuing a straight course even when endowed with a small velocity. Chapman also indicated how observation on the variation of the ionisation content in the E and F layers during a solar eclipse could decide the relative efficacies of the two types of radiation.[76] Experiments carried out during the solar eclipse of Aug. 31, 1932, in Europe and Canada[77] and of Aug. 21, 1933, in Calcutta by Mitra, Rakshit, Syam, and Ghose[78] indicate, however, that the ultra-violet light is the principal, if not the only cause of ionisation, and that the corpuscles have little or no effect. Fig. 14 depicts the variation of the ionisation content as measured during the last solar eclipse. There is a marked depression in the ionisation during the optical eclipse.

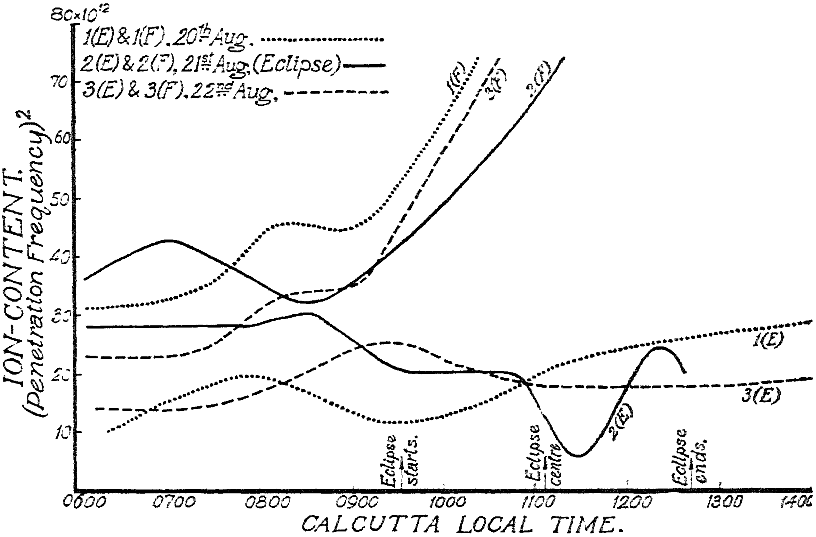

FIG. 14. Illustrating the variation of ionisation content of the E and the F layers on Aug. 21, 1933 (Solar eclipse) and on the days preceding and following. There is a marked diminution in the E layer ionisation immediately after the centre of the eclipse. Observations made at Calcutta.

The theory of Hulbert[79] that the ionised region separates into two banks after sunset as a result of temperature diffusion and electric-magnetic drift is also open to criticism. Appleton's suggestion that the four layers, E, E', F' and F, are due to the ionisation potentials of oxygen and nitrogen atoms and molecules of the upper atmosphere is interesting. More definite information about the atmospheric constituents at such high altitudes is necessary before any thing can be said about this theory.

Regarding the origin of ionisation of the E or the Kennelly-Heaviside layer mention must be made of one significant fact. The average height at which the maximum brightness of the meteors occurs[80], the average height of the most frequent appearance of the aurora borealis[81] and the height at which the composition of the atmosphere begins to change by a rapid diminution of the nitrogen content and (supposed) increase of helium content[82] are all nearly the same as the height of the region of maximum ionic density of the E layer, namely, round about 90 to 100 km. Whether this is a mere coincidence or if there is some causal relation between the various geophysical phenomena future investigations will only show.

CONCLUSION.

Before closing my address I shall refer to a subject which, though not coming strictly under the purview of my address, is still sufficiently closely related to it and is of sufficient importance to warrant a few remarks. The subject is the possibilities of broadcasting in India as a means of spreading education, of carrying propaganda work and of disseminating useful informations regarding rural health, agriculture, etc. The U.S.S.R. has grasped the immense possibilities of broadcasting and is utilizing it to the fullest extent for mass education by introducing a sort of regional scheme of broadcasting and installing in villages what are called communal receivers. It is high time that the government of this country adopt similar method of disseminating knowledge which has many advantages over ordinary methods and is also far less costly. The recently developed ultra-short-wave below 10 metres[83] would be extremely useful for such purpose. As the area covered by such waves is strictly local and can be easily regulated there will be no interference with a neighbouring district programme. The aerial system is simple and less costly. There are no atmospherics. And, since, upwardly directed rays of such short-waves pierce the ionosphere at all possible angles of incidence there is absolutely no fading. The district towns can be the transmitting centres and the village schools can be the homes for the communal receivers. Standardized types of transmitter and receiver are needed for this purpose. No doubt, the research laboratories of the big universities in India where investigations on wireless are carried and the skilled engineers of the Indian State Broadcasting Service can undertake the design of suitable types of transmitters and receivers. The cost of the inauguration and the maintenance of such a scheme of broadcasting for villages and district towns is insignificant compared to the benefits accruing out of it.

I shall now conclude by summarizing the salient points of the subject of my discourse touched upon in course of my address. The advance in our knowledge of the mechanism of radio wave propagation round the earth has been made in two distinct stages. The first stage, beginning with Marconi's successful experiment in 1901 of sending signal across Atlantic by overcoming the curvature of its surface, sees physicists and mathematicians attempting the solution of the problem of propagation round the surface of an isolated conducting sphere. The inadequacy of the solution to explain the observed effects leads to the recognition of the intervention of a conducting upper strata of the atmosphere. The theoretical investigations of the physicists and mathematicians on the one hand and the experimental measurements of field strength of the practical radiotelegraphist on the other hand lead to the development of empirical formulas which are of great help to the latter in estimating the field strengths at places far removed from the transmitter. This is the era of long waves, of gigantic aerials, and of huge and powerful transmitting stations.

The second stage, beginning with the end of the world war in 1919, which also is the era of thermionic valve and of broadcasting, sees the advent of short-wave. With the discovery of remarkable distance reaching properties of short-wave the field strength formulas evolved by 20 years of research and labour are found to break down. It seems as if the days of long waves and of huge aerials are over. Physicists and mathematicians make searching inquiry into the mode of propagation of short-wave in the conducting upper atmosphere to which a new name—the ionosphere—is given. The celebrated Eccles-Larmor theory is formulated. We see that the mode of propagation of short-waves is radically different from that of long waves. In one case (the latter) the propagation is *between* the earth and the ionosphere in the manner of a beam of light confined between a pair of parallel mirrors and in the other case (the former) the propagation for over long distances is *in* the ionosphere itself. Methods of sounding the ionosphere by upwardly directed trains of wave packets are developed which yield invaluable information regarding the conditions, physical properties and the structure of the ionosphere. Simultaneously the magneto-ionic theory taking into account the gyratory motion of the charged particles due to the earth's magnetic field is evolved which explains many hitherto unexplained phenomena. The last few years in the present stage of development have almost been of feverish activity. Much has been accomplished but much still remains to be achieved. For instance, little is known about the constituents of the upper atmosphere at ionospheric levels. Our knowledge of the nature of the ionising agencies other than sun's rays is still meagre. The origin of the double layer of maximum ionisation, not to speak of the finer structure, is still shrouded in mystery. It is hoped, however, that the intensive research work on ionospheric conditions which is being carried on will solve not only these, but along with them many other geophysical mysteries in near future.

I shall now project two films. The first one taken by ourselves depicts echoes of wireless signals as observed on the screen of the cathode ray oscillograph connected to the recording system. The unsteady nature of the indirect echo signal and its violent fluctuations at certain hours and in certain seasons are particular features to be noted. The second one, which I am able to show through the courtesy of Sir Frank E. Smith, K.C.B., F.R.S., Head of the Department of Scientific and Industrial Research, England, and for which I am extremely grateful, depicts the radiation of electric field from the transmitting aerial after the classical theory of Hertz.

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Section of Mathematics and Physics.

Abstracts.

1. The band spectrum of phosphorous nitride.

P. N. Ghosh *and* A. C. Datta, Calcutta.

No band spectrum due to the combination of nitrogen with phosphorus in the vapour state has yet been recorded in literature. The authors have obtained a system of red degrading bands lying in the ultra-violet region extending from λ 2780 to λ 2380 in the spectrum of an uncondensed discharge at about 1,500 volts through a mixture of nitrogen gas and phosphorous vapour. From their general appearance and conditions of formation these bands are ascribed to the diatomic molecule, *PN*.

The discharge tube was constructed of pyrex about 1 cm. bore and was fitted with internal electrodes of aluminium. Pure nitrogen gas was allowed to stream through the tube at about 1 cm. pressure of mercury and the vapour of phosphorus was led into the stream by heating a small stick of dry yellow phosphorus contained in a side tube. The bands are very much susceptible to the magnitude of the applied voltage as well as the pressure of the gas inside the tube.

Twenty-three band heads have so far been measured forming five distinct sequences and their vibrational quantum analysis shows that they have the following constants in cm^{-1} :—

$$\nu_e = 39818{\cdot}2$$
$$\omega_e' = 1100{\cdot}5\ ; \quad \omega_e'x_e' = 6{\cdot}8$$
$$\omega_e'' = 1337{\cdot}0\ ; \quad \omega_e''x_e'' = 7{\cdot}0$$

The bands show distinct *P* and *Q* heads and their structure lines appear to be resolved at some distance from the origin in the spectrum taken with Hilger E_1 Quartz Spectrograph. From the simplicity of the structure and the distinct *R* and *Q* heads they may be supposed to be due to a $^1\pi \rightarrow {}^1\Sigma$ or $^1\Sigma \rightarrow {}^1\pi$ transition. Their rotational analysis is now in progress with the help of a large concave grating.

2. On bands due to a new type of potassium vapour molecules.

S. Datta *and* B. K. Chakravarty, Calcutta.

As early as 1922, one of the authors discovered the existence of a number of new lines associated with the Principal absorption lines of Potassium vapour (*Proc. Roy. Soc.*, Vol. 101). The origin of these lines could not then be explained. Later in 1932, the present authors succeeded in proving the existence of similar lines in other alkali metal vapours, such as Sodium and Rubidium. They also succeeded in correlating the intervals of these lines from the associated Principal line with the difference between the vibration levels of the corresponding molecules, thus tracing their molecular origin—the exact nature of which could not then be properly understood. The work has since been repeated at still higher pressure. This has revealed the presence of a whole series of vibrational heads associated to each Principal series of which those previously recorded were earlier members. The analysis of these heads into a single progression has been found possible. This together with the fact that the electronic energy term is practically the same as that of Potassium atom suggest that the bands must be due to loosely bound Van der Waal type of molecules which under light absorption is transformed into Potassium molecules endowed with vibrational energy.

A new ultra-violet absorption band extending from λ 2950 to λ 2590 has also been observed. These are presumably due to the ordinary type of spin-coupled Potassium molecules.

3. Note on the vibrational classification of the ultra-violet and infra-red bands of Ammonia.

S. Datta *and* K. G. Mazumdar, Calcutta.

In a recent paper J. K. Dixon (*Phy. Rev.*, May, 1933) gave a tentative classification of the ultra-violet bands of Ammonia in which some of the bands could not be classified and even in those that were classified the agreement between the observed and the calculated values were far from satisfactory. The same remark can be made with regard to the infra-red bands of Ammonia measured and classified by Robertson and Fox (*Proc. Roy. Soc.*, 1932). In the present note a better assignment for all the bands has been suggested.

4. Sulphur bands.

R. K. Asundi, Aligarh.

The bands have been photographed under low temperature conditions. They appear to be triple-headed, the strongest being the one on the higher wavelength-side and is the one which is invariably recorded by previous workers. The following heads (in each case only the strongest one) till now unrecorded, have been assigned :—

$(v'\ v'')$.	λ Int.	ν. (vac).
9, 32	6612·3(8)	15119
8, 31	6545·0(7)	15275
7, 30	6476·3(5)	15437
9, 31	6382·7(10)	15663
8, 30	6316·7(9)	15827
7, 29	6251·5(8)	15993

5. Intensities in N_2-second positive bands under different conditions of excitation.

N. R. Tawde, Bombay.

Correct estimates of peak intensities of bands in this system ($c^3\pi \rightarrow b^3\pi$) have been made. The bands have been observed in (*a*) positive column in air, (*b*) argon-nitrogen mixture, (*c*) high-frequency electrodeless discharge, and (*d*) spark in air. The system has been photographed on E_1 quartz prism instrument. The quantitative data has been corrected for the energy distribution of a calibrated tungsten lamp and the sensitivity of the photographic plate. The general technique of intensity is the same as used by Johnson and Tawde (*Proc. Roy. Soc.*, 137, 575, 1932) on C_2-Swan bands. The results calculated for the vibrational transition probabilities agree in a general way with the predictions of Franck-Condon Theory. The temperatures derived for different conditions show that populations in various vibrational levels are not in statistical equilibrium with their surroundings.

6. The band spectrum of silicon hydride.

N. R. Tawde, Bombay.

After the work of Jackson (*Proc. Roy. Soc.*, 126, 373, 1930) on bands of SiH near λ4142, Mulliken has given a different interpretation to λ-type doubling found in these bands. In view of this, exhaustive rotational analysis of these bands under higher dispersion has been undertaken. The bands have been photographed in the second and third orders of 21-foot concave grating of the University of Stockholm, Sweden. The analysis is proceeding.

7. The intensity distribution in the bands of violet *CN*-system.

N. R. Tawde, Bombay.

The quantitative data on intensities within a band system are very rare. In view of this, by comparing the bands of this system as obtained in carbon arc with the calibrated blackenings produced on a photographic plate, estimates of intensities have been undertaken. The bands of so-called ' tail-system ' have also been included to calculate the vibrational transition probabilities.

8. Fluorescence in Sandal Oil.

L. Sibaiya *and* N. A. Narayana Rao, Bangalore.

A spectroscopic examination of the mercury arc light scattered by a pure sample of Sandal Oil revealed in the red region two fluorescence bands with intensity maxima at about 6016 Å and 6468 Å, the former band being more than thrice as intense as the latter. Sandal Oil is found to absorb markedly λ 4358 Å group, and λ 4047 Å group is completely absorbed. Using suitable filters to alter the intensity of λ 4358 Å group in the exciting radiation, no variation in the intensity of the fluorescence bands is observed; it is concluded that the bands are mainly excited by λ 5461 Å. They exhibit strong polarization with an estimated depolarization ratio less than 0·1: this fact indicates that Sandal Oil which is a liquid mixture contains molecules with no pronounced optical anisotropy. As the temperature is increased, the fluorescence bands fall off considerably in intensity, thus indicating a dissociation of the molecular aggregates responsible for the fluorescence.

9. An investigation of the fine structure of the Spectrum lines of Manganese, Part I (Visible Region).

Wali Mohammad, Lucknow.

The author's method of using an arc in vacuum produced by means of a coated cathode and anode of the given substance has been used as a source of light. The light is analyzed by means of a Hilger 3 metre Spectrograph and two large-sized Lummer Quartz Plates. The structure of the various lines has been studied and the position of the satellites determined.

10. Hyperfine structures in the Spectrum Sb III.

J. S. Badami, Bombay.

In continuation of the work of the author on the nuclear spins of antimony isotopes and the hyperfine structures of antimony spectral lines, (*Z. f. Phys.*: Band 79, pp. 206 and 224, 1932) the two doublets

$$5s^2 . 6s\,{}^2S_{\frac{1}{2}} - 5s^2 . 6p\,{}^2P_{\frac{1}{2},\frac{3}{2}} \quad (\lambda\lambda\, 4591{\cdot}89 \text{ and } 4265{\cdot}09)$$

and

$$5s . 5p^2\,{}^2S_{\frac{1}{2}} - 5s^2 . 6p^2P_{\frac{1}{2},\frac{3}{2}} \quad (\lambda\lambda\, 4692{\cdot}91 \text{ and } 4352{\cdot}16)$$

of the Sb III spectrum were examined using Fabry-Perot etalons. The source was a condensed discharge through a mixture of helium and antimony vapour.

Each line showed two diffuse components, that to the longer wavelengths being the stronger, the visually estimated intensities being about 4 : 3. Separations of the components for each line are given below in wave-numbers to two places of decimals:—

λ	$\Delta\nu$
4265	1·27
4352	0·45
4592	1·40
4693	0·55

The term $5s^2 . 6s\,{}^2S_{\frac{1}{2}}$ shows the largest splitting; $5s . 5p^2\,{}^2S_{\frac{1}{2}}$ comes next. The splittings of the ${}^2P$ terms are evident in the inequality of the structures of $\lambda\lambda$ 4265 and 4592 or of $\lambda\lambda$ 4352 and 4693.

11. Hyperfine structure of Iodine lines.

S. N. Kaw, Lahore.

The source of light was a glass tube filled with iodine vapour at a pressure of less than ·1 mm., round which an electrodeless ring discharge was passed. This device was found to be quite suitable for producing extremely narrow lines. The hyperfine structures were observed with a 20 cm. long glass Lummer and Gehrcke plate placed in conjunction with a spectroscope. Many lines show fine structure, some of which have been measured. The structures of others are in the course of measurement. Most of these lines belong to the spectrum of doubly ionized iodine.

12. Spectrum of Ca VI.

Mela Ram, Lahore.

In continuation of the work which has been recently completed on the analyses of the spectra of calcium in successive stages of ionization (in Press), the author has now succeeded in classifying a large number of the lines of Ca VI in the extreme Schumann region with the help of the data provided by E. Ekefors (*Zs. f. Phys.*, Vol. 71, p. 53, 1931). It is shown that this is very similar to the spectrum of KV which has also been done by the author.

13. Spectra of Iodine.

Prannath Kalia, Lahore.

The paper gives lists of the lines of iodine in various stages of ionization, which have been measured between λ 1300 to λ 2500 with a one-metre vacuum-grating spectrograph set up in the Physics Laboratory of the Government College, Lahore. The Schumann plates used were prepared by Mr. Balmukund Anand.

14. Spectrum of singly-ionized Krypton.

S. Basu, Patna.

The author has photographed the lines of singly-ionized Krypton with a large Hilger spectrograph in the region between λ5200 to λ6600. In all 81 new lines have been measured and tabulated. The classification is proceeding.

15. Fraunhofer Spectrum.

Mela Ram, Lahore.

Spectrogram of solar radiation show complete absorption by the ultra-violet light below λ 2975. The present writer was a member of the Cosmic Ray Expedition that proceeded to the Himalayas in the summer of 1932. The opportunity thus afforded was utilized to take some solar spectrograms in order to find out if even at great heights where the absorbing layer of the atmosphere had considerably diminished, the limit of atmospheric absorption was the same as lower down. A small quartz-spectrograph was used for the purpose and observations were taken at heights ranging from 16,000 ft. to 18,000 ft. above sea-level at such places as Kyelang, Baralacha Pass (16,600 ft.), and Laya Lun (18,000 ft.). All the plates showed complete absorption below λ 2975, showing that the layer of the air below 18,000 ft. does not contribute to the absorption of the ultra-violet light, and confirmed the belief that the absorption is due to the upper layers of the atmosphere.

16. Study of the absorption spectra of calcium subiodide in the near infra-red, extreme red, visible and the ultra-violet regions.

Muhamad Zakiuddin, Aligarh.

The paper deals with an attempt to study the absorption spectrum of the diatomic subhalide Ca I, which has been many times prepared during the investigation. The chief difficulty encountered and which has not been overcome till now, as is evident from the nature of the results obtained, is the want of a suitable liquid in which the substance could be preserved. Various Organic Liquids were tried and Carbon Bisulphide was found to be the only one in which the substance appeared to be safe but even this is shown to react with the substance.

This is evident from the fact that the absorption indicates presence of Sulphur in addition to Iodine while apparently showing no indication of the molecule sought.

17. The study of the absorption spectra of $CoCl_2, 6H_2O$; $NiCl_2, 6H_2O$; $CuCl_2, 2H_2O$; $MnCl_2, 4H_2O$; $FeCl_3, 6H_2O$; $CuCl$; $FeCl_3$; Na_2CrO_4; $K_2Cr_2O_7$; $KMnO_4$; $CrCl_3, 6H_2O$; $RuCl_3$; VCl_3; $RhCl_3$; $PdCl_2, 4H_2O$; $IrCl_4$; $OsCl_4$; and YCl_3; in the ultra-violet region and the visible region of the spectrum.

M. Karim *and* R. Samuel, Aligarh.

The absorption spectra of the above-mentioned inorganic simple salt solutions were studied in the region mentioned above, and the absorption curves were drawn in order to investigate the problem of electronic linkage in chemical compounds.

A comparison between the absorption bands in solution and the term values of the corresponding ions shows that though in some cases there is an agreement between the absorption bands in solution and the term values of the ions which we normally expect to be present in the solutions, there are a large number of cases in which we can identify the absorption bands with the term values of the ions in less ionized state. which we normally do not expect to find in the solution. The number of such coincidences is too large to be explained away as a mere matter of chance coincidence. Assuming therefore that this coincidence is not fortuitous, we can assume that wherever we get such coincidences the Absorption Maxima observed are due to ions of compounds which are extremely unstable.

18. Line absorption spectra of ions of the first transition group in solutions.

S. Datta, Calcutta.

In addition to the familiar broad absorption bands, some fairly sharp lines (as is characteristic of the rare earth salts) have been observed in the absorption spectra of certain solutions of $CrCl_3$ and $CoCl_2$. Concentrated aqueous solutions of violet $CrCl_3$ gives two absorption lines and concentrated aqueous solutions of $CoCl_2$ gives five absorption lines, in both cases on the longer wavelength side of the broad absorption bands. These absorption lines are to be attributed to free ions which have broken up association with water molecules and are probably due to the ${}^4F-{}^2G_{4,\,5}$ transitions in the case of Cr^{+++} and also to some similar transition in the case of Co^{++} ions. Microphotometric measurement of intensity of the lines in the absorption spectra of Co^{++} with a solution of definite concentration of $CoCl_2$ indicates that the intensity increases remarkably with temperature (vanishing at low temperatures) and also with concentration of the Cl^- ions. These results seem to afford confirmation of the view developed by Bose and the writer previously where it was shown that when the energy of thermal oscillation $u > A$, the energy of coupling of the central paramagnetic ion with dipole molecules, the latter breaks down and out of a total n_0 ions $n = n_0\left[1 - f\left(\frac{A}{T}\right)\right]$ exist as free ions and give rise to the line absorption. The number n increases with the temperature T.

19. On the nature of the absorption centres in solution containing paramagnetic ions and the mechanism of light absorption in them.

S. Datta *and* D. M. Bose, Calcutta.

The authors have discussed the nature of absorbing centres in aq. solutions containing paramagnetic ions of the iron group and have explained why the absorption maxima is in the shorter wavelength side with respect to the emission lines for the same ion. Later exptl. work on the absorption spectra of solutions of $CrCl_3$, $MnCl_2$, $CoCl_2$, $NiCl_2$, etc. in water as well as in et. alcohol and HCl with the spectrograph and the Hilsch double monochromator show that in the latter solvents the absorption spectra in the visible region is shifted towards the longer wavelength side with respect to that due to the hydrated complex. The edge of continuous absorption in the ultra-violet region in the latter solutions is shifted to a much longer wavelength side; in certain cases there being a pronounced maxima followed by a retransmission in the further ultra-violet. For $CrCl_3$ solutions the absorption spectra in the visible as well as the absorption edge in the ultra-violet approaches towards that due to $CrCl_3$ vapour given by Saha and Deb. The paramagnetic ions in these solutions exist in a new form of aggregation other than as complexes, probably as homopolar chlorides. At very low temperatures again even in these solutions the absorption spectra assumes the form as due to hydrated complexes. The reason why the absorption spectra is shifted towards ultra-violet for hydrated complexes and not so far homopolar molecules is, as suggested by Bose, to be explained on the assumption that in the hydrated complexes the ground level of the ion is distorted due to the potential field of the associated molecules but in the excited metastable state, the complex breaks up and the ion is no longer under the influence of such an electric field, whereas in the case of homopolar molecules both in the ground state as well as in the excited state the ionic terms are similarly distorted by the electric field, the state of aggregation remaining the same throughout.

20. Study of the luminiscence of a vacuum arc lamp.

S. B. L. Mathur *and* J. M. Patel, Bombay.

The appearance of various lines under different conditions of discharge in a vacuum lamp have been studied.

21. Measurement of the absolute rate of migration of Ions by the Moving Boundary Method.

J. N. Mukherjee, R. P. Mitra, *and* J. Bagchi, Calcutta.

Preliminary measurements of the rates of migration of electrolytic ions under known potential gradients by the Moving Boundary Method have been described.

22. On the relation between the optical and magnetic properties of some paramagnetic solutions.

D. M. Bose, Calcutta.

In a paper recently published (Bose and Datta, *Zeit. f. Phys.* 80, 376, 1933) it has been shown that the properties of paramagnetic solution can be largely explained by the assumption that in aqueous solutions the paramagnetic ions exist in the form of complexes $[Me\ n\chi]^{m+}$, where χ is a dipole molecule like H_2O, NH_3, N_2H_4, etc.; the complexes are formed due to an interaction between the ion and the associated dipole molecules. If W_1 and W_2 are the energies of the free ion in the initial resp—the excited state, and A_1 and A_2 are the work done in forming the complex in these two states, then the frequency of absorption by the ion is given by

$$h(\nu-\nu_0)=A_1-A_2 \ldots\ldots\ldots (1)$$

where $h\nu=W_2-W_1$, the absorption frequency of the free ion. If during the process of light absorption the complex is dissociated and the average life of the ion in the excited state is small, then instead of A_2 the average work done per ion in the excited state is taken to be βA_2, where $\beta << 1$ and

$$h(\nu-\nu_0)=A_1-\beta A_2 \ldots\ldots\ldots (2)$$

In the ground state the work A_1 done on the ion leads to a quenching of the orbital moment of the ion, whose magnetic moment is now given by

$$\mu=4{\cdot}97\sqrt{4s(s+1)+l(l+1)f\left(\frac{A}{T}\right)}$$

$$\text{Where } f\left(\frac{A}{T}\right)=1, \textit{ for } \frac{A}{T}=0;$$

$$=0, \textit{ for } \frac{A}{T}=\infty.$$

In this way a number of correlations between the magnetic moment of an ion in solution and the position of its absorption maxima as function of $\frac{A}{T}$ have been found, and the photomagnetic effect shown by these solutions can be interpreted.

Recently S. Datta has found that for certain paramagnetic chlorides dissolved in hydrochloric acid or in anhydrous alcohol, the above correlation between the position of the absorption maximum and the magnetic moment of the complex does not hold, and he has found experimental evidence that in these solutions the paramagnetic ion does not exist as a complex but as homopolar chlorides. Raha has found that these solutions show a photomagnetic effect negligibly small compared to that shown by a hydrated complex of the same ion. These results can be interpreted by (i) if we assume that the homopolar paramagnetic chlorides in solution are not dissociated by light absorption, so that the orbital moment of the ion remains quenched both in the initial and in the excited state. The photomagnetic effect which depends primarily on the restoration of the orbital moment of the ion will then be negligibly small. Further from the relation (1) a much smaller shift in the position of the absorption maxima of the covalent bound ion is to be expected in comparison to that due to the complex ion; this is in agreement with experimental results.

23. Studies in photomagnetism.

P. K. Raha *and* D. M. Bose, Calcutta.

This is a continuation of the investigation already reported in the *Zeit. f. Phys.* (80, 360, 1933) by means of a new arrangement which enables a quantitative estimate of the change in susceptibility. The apparatus used is a modification of the O-tube method used for the measurement of the susceptibility of gases under pressure. The meniscus of the paramagnetic solution enclosed in the horizontal capillary portion of the arrangement is placed in a strong magnetic field, and the shift in the position of the meniscus due to the absorption of radiation from a Hg. arc by the solution is observed. By changing the pressure of the enclosed air the meniscus is brought back to its original position, and the increase in gas pressure enables the change in susceptibility of solution to be calculated. In all solutions where a susceptibility change is observed, it represents an increase of the order of 1 in 10^6. It was noted that while hydrated complexes of Cr^{+++} and Ni^{++} in aqueous solution showed definite increase in susceptibility, the HCl solutions of the same concentration of these ions fail to show any measurable change, though the percentage of light absorption remains of the same order. The significance of this observation is discussed in a subsequent paper.

24. The Ferromagnetism of Nickel.

S. Ramachandra Rao, Annamalainagar.

Nickel colloid was prepared by passing an intermittent electric arc from an induction coil between two pure nickel electrodes enclosed in normal propyl alcohol. The magnetic properties of nearly uniform particles, weighing in all about 3 to 5 milligrammes, were investigated in small bulbs, in the presence of relatively larger quantities of propyl alcohol. The specific intensity of magnetization of the powders was only about 70% of the mass value and finer particles showed a lower value. Since the work was conducted in vacuum, oxidation of nickel was unlikely and hence the lowering seems to be due to colloidalization. The powders did not show any residual magnetism. These results seem to lend support to the theories of ferromagnetism suggested by Heisenberg, Bitter, and Zwicky. The larger number of broken microcrystals on the surface of the small particles will not contribute anything to the ferromagnetism of the particles and thus the lowering of the specific intensity of magnetization with decreasing particle size seems to be theoretically justifiable.

25. Nuclear magnetic moments.

B. VENKATESACHAR *and* T. S. SUBBARAYA, Bangalore.

In an attempt to explain the observed nuclear spins of various elements the view was put forward by the authors (*Current Science*, 1, 120, 1932) that all nuclei consist of α-particles and neutrons with an extra proton in the case of odd Z. The same conclusion has been reached from a consideration of mass defects and radioactive transformations by Gapon (*Zs. f. Phys.*, 79, 676, 1932; 84, 509 and 520, 1933) and Landé (*Phys. Rev.*, 43, 620 and 624, 1933). It is known that a spin of $\frac{1}{2}\frac{h}{2\pi}$ is to be ascribed to the neutron, but cases like Cl_{35}, where, with only two neutrons present, a spin of $\frac{5}{2}$ is to be explained, show that an orbital moment is also to be ascribed to the neutron. Starting with this idea and assuming that the same relations hold between the spin and orbital moments of neutrons as exist between those of extra-nuclear electrons, the authors have shown (*Zs. f. Phys.* In course of publication) how an understanding of the nuclear magnetic moments deduced by Goudsmit (*Phys. Rev.*, 43, 638, 1933) can be reached. In the meanwhile an article by Fermi and Segre (*Zs. f. Phys.*, 82, 729, 1933) has appeared wherein results nearly identical with those of Goudsmit have been arrived at. This paper contains a discussion of the nuclear magnetic moments of Na, Ba, and Au in addition to those of elements previously considered. Taking the neutronic terms to be $^3S_1$, $^2F_{5/2}$, and $^3P_1$ in the case of Na, Ba, and Au respectively, we have calculated the nuclear magnetic moments by the previous method and find them to be 2, 1·07 and 1·75 proton magnetons, as compared with the values 2·09, 1·05 and 1·82 deduced by Fermi and Segré from h.f.s. data.

26. Raman spectra of some paramagnetic chlorides in solution and the nature of the valency binding in them.

S. DATTA, Calcutta.

The magnetic behaviour as well as the absorption spectra of solutions of paramagnetic chlorides of the iron group indicate that in et. alcohol or HCl solutions the paramagnetic ions exist in a new form of aggregation other than as complexes of the type that exists in aq. solutions, probably they exist in the form of homopolar chlorides. The tendency for molecule formation increases with the lowering of dielectric constant of the solvent or increase the concentration of Cl^- ions the tendency for formation of hydrated or alcholated complexes increases with the lowering of temperature. Further evidence to support the above conclusions has been collected from the study of Raman spectra of some of these solutions. The paramagnetic salts of this group have strong absorption in the visible region of the spectrum and it is very difficult and in some cases impossible to obtain their Raman spectra. Raman lines of small frequency shift (of the order of 100 cm^{-1}) have been obtained with an exposure of about 10 hours. With solutions of $COCl_2$ in et. alcohol and $MnCl_2$ in et. alcohol and concentrated HCl though aq. solutions of equal concentration gave no such Raman lines under exactly similar condition of exposure. For comparison $ZnCl_2$ solutions in et. alcohol and concentrated HCl and $CdCl_2$ solutions in concentrated HCl were investigated and fairly strong Raman lines were obtained after an exposure of 8 hrs. and corresponding aq. solutions gave no such lines for similar exposure. The appearance of Raman lines in the group of solutions indicated the existence of covalent linkage between the cation and anion, and their absence in the case of the complex ions indicate that only electrostatic forces at between the central ion and the dipole water molecules. Attempts are being made to photograph the Raman spectra of some of the above solutions in et. alcohol or HCl at very low temperature in which the ions are supposed to exist in the form of hydrated or alcoholated complexes.

27. Rotational Raman effect in liquids.

S. BHAGAVANTAM, Waltair.

The experimental results regarding the rotational Raman spectra in liquids when compared with those in gases indicate that the liquid state has ordinarily to be regarded as composed partly of *gaseous* molecules and partly of *solid* molecules. Examples in which the molecules are mostly of the former type are liquid hydrogen, oxygen, etc., and the rotational patterns in these cases conform closely to the patterns obtained with the corresponding gases in all important respects, such as the structure and distribution of intensity. A typical case in which the molecules are mostly of the latter type is benzene and accordingly the features exhibited by the rotational spectrum of this liquid are very different from those that are characteristic of a gas. Application of Pauling's criteria for the rotational and oscillational motion of molecules in the solid state provides a test for the classification of liquids in the above manner.

28. Polarization of Raman lines in gases : CO and N_2.

S. BHAGAVANTAM, Waltair.

The state of polarization of the vibrational Raman lines in CO and N_2 has been obtained, employing the standard methods of intensity measurement. The line in CO has a frequency shift of 2141 cm^{-1} and a depolarization value of 0·12 whereas in nitrogen the line is shifted by 2330 cm^{-1} and exhibits a depolarization value of 0·2. These figures are of the same order as in other diatomic molecules, such as oxygen and hydrogen, investigated earlier by the author.

29. Polarization of X-rays emitted from a thin anticathode.

H. P. DE, Calcutta.

A beam of cathode rays was made homogeneous by means of a system of slits placed in a magnetic field, perpendicular to their direction of motion, and impinged normally on a thin aluminium anticathode ($1{\cdot}2\mu\mu$). The state of polarization of the continuous X-rays emitted in directions making different angles with the direction of the primary beam was studied by allowing the X-rays to pass into a Wilson chamber, and the tracks of the ejected photo-electrons were photographed by a stereocamera. The initial direction of ejection of a photo-electron was measured for each track by a stereo-micrometer. The state of polarization is defined by the ratio $\frac{N_P-N_R}{N_P+N_R}\times 100$ where N_P represents the number of photo-electrons emitted in the horizontal direction (i.e. in the plane containing the X-rays and the cathode rays) and N_R represents those in the vertical direction. It was found that at right angle to the incident cathode ray beam the state of polarization is about 50% and along a direction making an angle of 30° with the incident cathode ray beam the state of polarization is about 11%. This experiment was undertaken to test the various theories proposed to account for the state of polarization of the continuous X-rays from thin anticathodes.

The experimental results are not sufficiently accurate to verify the theories proposed; owing to several reasons amongst others, due to the lack of homogeneity of the anticathode used and due to the presence of a small amount of scattered X-rays present in the beam passing through the expansion chamber.

30. The anomalous scattering of α-particles.

K. K. Mukherjee, Serampore.

In a recent paper, published in *Phys. Zeit.*, 34, 175, 1933, on the anomalous α-scattering, the author has established by Wave Statistical method, the formula

$$D/D_0 = \left| 1 - \frac{4\pi^2 r_0^2}{\lambda^2} \sin^2\theta/2 \Big/ \cos\left(\frac{4\pi r_0}{\lambda} \sin \theta/2\right) \right|^2;$$

where D_0 denotes the number of particles scattered with Coulomb force D the number when the additional polarization force is supposed to vary, as $\frac{1}{r^5}$, θ the angle of scattering, γ the wavelength and r_0 the closest distance of approach of the α-particle from the centre of the nucleus. The values of D/D_0, calculated from this formula, are in very good agreement with the experimental values of Bieler for aluminium and magnesium, and with the very large values of Chadwick for scattering at large angles, by carbon, boron, and beryllium. Our calculated values are in remarkable agreement also with the experimental results of Rutherford and Chadwick for helium, of Reizler for boron and carbon, and of Bieler and Chadwick for hydrogen. In the above formula r_0 has been taken to be a constant, though strictly speaking it should be a function of θ and also the range of the α-particle. These small variations of r_0 have been studied and they lead to many important informations regarding the structure of the nucleus, for instance, they suggest the existence of nuclear magnetic shells in the case of some elements, viz. boron and carbon.

31. Positrons and nuclear structure.

S. B. L. Mathur, Bombay.

In a recent note published in the *Journal of the American Chemical Society*, the author predicted the existence of some Isotopes assuming with Johnston, Gamow and others that the various nucleii consisted of helium nucleii, protons and free electrons. Recently, among others, Lande has studied the same subject and has shown how various nucleii are built of neutrons and α-particles as their main constituents. In the present paper an attempt has been made to derive the structure of various atomic nucleii in the light of the recent discovery of positrons.

32. A study of the effect of heat on the structure of thin films with the help of X-rays.

S. Rama Swamy, Bangalore.

In a communication to Twentieth Session of the Indian Science Congress (January, 1933) it was found that sputtered films of metal disintegrate on heating into aggregates separated from each other. The present work was taken up with a view to find out the effect of heat on the microcrystals forming the film of metal. Sputtered films of gold were heated to various temperatures and their Debye Scherrer photographs obtained after each stage of heating. The photographs showed on examination that the gold crystals in the film oriented themselves on heating, such that their 111 planes were parallel to the surface of deposition. The degree of orientation as obtained from the photographs was found to be a function of the temperature to which the film was heated. Further work on the subject is in progress.

33. X-ray studies of sputtered films of gold-copper alloys.

S. Rama Swamy *and* K. R. Krishnaswamy, Bangalore.

Gold and copper both belong to the face-centred cubic type of crystal structure whereas an alloy of the composition AuCu has a tetragonal structure. Copper and gold are known to sputter at different rates. If sputtering is a crystalline process and not a molecular process a sputtered film of the alloy AuCu should show the same crystal structure as the alloy. Hence by examining the X-ray diffraction patterns given by a sputtered film of the alloy AuCu it should be possible to find out whether sputtering is a crystalline or a molecular process. The present paper discusses the results obtained from experiments conducted on the above lines.

34. Absorption effects in the total secondary electron emission from metal faces.

S. Ramachandra Rao, Annamalainagar.

Two outstanding problems in the study of total secondary electron emission from metal faces have been the peculiar shape of the total emission curves and the differences observed between polycrystalline and single crystal faces. No explanations have so far been offered to account for these observations. An attempt is made in this paper to explain these results as being due to the absorption of the secondary electrons in the medium of the photo-electric target. An expression has been derived for the ratio (R) of the secondary to the primary current and it is found that the experimental results agree very satisfactorily with it. Additional confirmation has been obtained to show that the mean velocity of the secondary electrons decreases at higher potentials—rapidly at first and then more slowly. The equation is found to be true for single crystal faces and offers a natural explanation for the observed difference in the R values for the polycrystalline and single crystal surfaces. The influence of absorbed gases on the R values is also discussed.

35. Recording wireless echoes at the transmitting station.

B. N. Ghose, Calcutta.

The difficulties met with in recording echoes of upwardly directed wireless signals at places very near the transmitting aerial are two-fold. Firstly, when the receiver is brought near the transmitting aerial, the direct ground signal which is very strong, overloads the receiver and renders it insensitive for a period of the order of a few milli-seconds. Any echo which returns to the earth within an interval of this order, is naturally unable to affect the paralyzed receiver. Secondly in the interval between the transmitted pulses (which interval is of the order of $\frac{1}{200}$th of a second, duration of each pulse being $\frac{1}{4000}$th of a second) the transmitting aerial acts like a receiving aerial and absorbs energy from the down-coming echo. The receiver with a smaller aerial brought under the 'Shadow' of the transmitting aerial, naturally fails to record the echo. This second impediment which is of importance when the receiver is very near the foot of the transmitting aerial has been overcome by Mitra and Rakshit (*Nature*, Vol. 131, p. 657, May 6th, 1933) by coupling the input coil of the receiver to the tuning coil of the transmitting aerial. The present communication is on a simple device for overcoming the first-mentioned difficulty, namely that, due to the paralyzing effect of the strong ground signal. The device involves the use of a neon lamp inserted in parallel with the input tuning condenser which effectively prevents choking.

36. Measurement of the field-strength of wireless echoes.

H. Rakshit, Calcutta.

The problem of the measurement of echo field-strength presents certain peculiarities not met with in the ordinary field-strength measurements as were done for the field strength survey of Calcutta (Rakshit, *Phil. Mag.*, 11, 174, 1931). Firstly, since the field-strength at any point is due both to the direct signal and to the echo, the transmitting and the receiving systems must be so arranged as to enable the direct signal being separated from the echo. This is accomplished in the group-retardation method by sending short duration pulses and receiving them on a cathode ray oscillograph. Secondly, the calibration of the receiver assembly employed in this case has to be carried out differently from that of the receiver assembly employed for the ordinary field-strength measurements. Since in this case the transmitted signal is in the form of short duration pulses, the input voltage for calibration should also be by pulses of known intensity and of frequency equal to that of the pulses from the transmitter. A receiver calibrated in this manner in conjunction with a receiving loop aerial of known constants can be employed for measuring the strength of the echoes.

It has been found that the echoes are abnormally strong during the sunset and the sunrise periods. A probable explanation of such abnormality is given.

The reflection coefficient of the ionosphere has also been measured by comparing the observed echo strengths with the values obtained from theoretical considerations.

37. Depth of penetration of wireless waves inside the conducting layer of the Ionosphere from observations on magnetic splitting.

H. Rakshit, Calcutta.

The effect of the earth's magnetic field on the motion of the charged particles in the ionized layer is to cause the latter double-refracting. In the simplest case a single transmitted pulse will, on entering into the ionized layer, be split up into two components, one ordinary and another extraordinary. The two components will travel with different group velocities and be reflected from different heights of the ionosphere, the extraordinary component reaching the earth earlier than the ordinary component. From a knowledge of the time interval between these two components and the average group velocity of the ordinary waves within the depth penetrated, we can calculate the depth of penetration of the ordinary component beyond the place of reflection of the extraordinary component. The greatest depth of penetration that has so far been recorded at Calcutta during the last Polar year (1932-33) is 51 km.

38. Measurement of the Ionization content of the conducting layers of the Ionosphere.

P. Syam, Calcutta.

The ion contents of the two conducting layers of the upper atmosphere have been measured, after Appleton, by observing the frequency at which the upwardly directed waves just pierce either the lower or the upper layer. The frequency range employed was from 8650 to 1220 kilocycles. A number of 24-hour continuous observations has been made.

The average hourly variation of ionization has been found to agree approximately with the theoretical calculations of Chapman deduced by considering the ionization as due to the absorption of homogeneous monochromatic radiation in the earth's atmosphere. Further investigations along this line are being continued. (Some of the preliminary work in this connection was done by H. Rakshit.)

39. Radio-field-strength survey of the town of Dacca.

S. R. KHASTGIR *and* D. N. CHOUDHURY, Dacca.

The results of a systematic radio-field-strength survey of the town of Dacca, λ 181·5 m., have been given and a contour map has been constructed showing lines of equal field-strength.

The Antenna effect in the calibrated receiver is eliminated by an electrostatic shielding between the grid and the loop coils. The method claims simplicity and effectiveness, even for shorter wavelengths.

The radio-field-strength contour map shows that the propagation of waves is slightly better near the river area. The maximum effect observed in the north-south direction in the immediate neighbourhood of the transmitter has been attributed to the directional effect of the aerial. This irregularity, however, is wiped out at comparatively larger distances. The local electrical power house has been found to exert considerable influence on the contour lines in its neighbourhood.

The striking thing in the measurements is the abnormally large value of attenuation in all directions round the transmitter. The observed high attenuation is far too high to be explained on any theory of ground absorption. It seems certain that owing to the peculiar layout of the transmitting aerial, electromagnetic waves are mostly concentrated in the upward direction, thus causing large attenuation on the horizontal surface.

40. Measurement of the electrical properties of the earth at radio frequency.

S. R. KHASTGIR, Dacca.

Direct determinations of the electrical conductivity and the dielectric constant of the specimens of Dacca soil were undertaken in connection with the radio-field-strength survey of the town of Dacca. The method of Ratcliffe and White was adopted in a slightly modified form. The soil-condenser was a cylindrical condenser made of two co-axial brass cylinders, one going inside the other. The intervening space between the cylinders was carefully filled with the specimen of the soil. A plate condenser was also tried. Different specimens of the soil were examined for frequency equal to $1·652 \times 10^6$ cycles per sec. ($\lambda = 181·5$ m.). The following values were obtained under normal moisture conditions. (The percentage of moisture to dry soil by weight was about 20%):—

$$\epsilon = 39 \text{ e.s.u.}, \quad \sigma = 2·2 \times 10^{-14} \text{ e.m.u.}$$

While Ratcliffe and White's and Strutt's values were of this order of magnitude, Smith-Rose's recent determination has yielded a larger value for the electrical conductivity. The considerable change in the values of σ and ϵ with the moisture content of the soil was also observed. The specimen of soil when dried gave the following values:—

$$\epsilon = 14 \text{ e.s.u.}, \quad \sigma = 3·7 \times 10^{-15} \text{ e.m.u.}$$

It is curious that the value of σ obtained by direct experiment with the Dacca soil (under normal moisture conditions) agrees at least in the order of magnitude, with the effective value of σ obtained from field-strength measurements at Calcutta by Rakshit. A discussion of the results are given.

41. On the critical condition for starting of oscillations in valve maintained oscillators of various frequencies.

S. S. BANERJEE, Benares.

The paper is concerned with the building up of valve oscillators of various frequencies, the range covered being from ultra-high frequency (λ 1·5 m.) to audio frequency. The condition for the starting of oscillations has been studied and a simpler theory for same (minimum value of M necessary) has been developed for the case of audio frequency. Details of the circuit arrangement are given and limitations of the commercial low-power valves in maintaining ultra-high frequency oscillations by regenerative process have been discussed.

42. On the resonance frequency of oscillatory circuits with leaky condenser and its bearing on the measurement of the dielectric constant of ionized gas.

S. S. BANERJEE, Benares.

The lowering of the dielectric constant of an ionized gas below unity which, according to Eccles-Larmor theory, is responsible for carrying radio waves round the curved surface of the earth has been the subject of much experimental investigation in recent years. On account of the conductivity of the ionized gas, however, the results obtained by different workers seldom agree with one another and are often of a conflicting nature. Attempts have been made by some investigators to eliminate the conductivity effect by measuring the 'voltage resonance' rather than the 'current resonance' on the assumption that the voltage resonance frequency of the experimental oscillatory circuit is independent of the conductivity of the ionized gas which forms part of the space between the plates of the oscillatory circuit condenser. This assumption has been studied critically in the present paper and it is shown theoretically and experimentally that the voltage resonance frequency is independent of conductivity only when the medium between the condenser plates is uniformly conducting.

If the conductivity is different at different points along the distance separating the plates of the condenser then the above assumption is no longer valid. It is shown that the anomalous results referred to above can be explained as due to the conductivity acquired by the gas owing to ionization.

43. Some reception measurements at Bangalore.

P. L. NARAYANA, Bangalore.

The intensity changes of the received radio signal from the 75 kc/s radio telegraph station at Madras have been recorded with automatic recording apparatus during the working hours of the station since February. The records show characteristic variations during the periods of sunrise and sunset but not on every day of recording. No regularity is apparent in the high and rapid fluctuations that occur during the night.

The broadcasting station at Bombay working on 841 kc/s can only be recorded after sunset and shows very deep and rapid fading.

44. Deposits of elements by high frequency discharge.

D. BANERJI *and* DHIRANJOY BHATTACHARYA, Calcutta.

In the study of the deposits of metallic mercury on the wall of a high frequency discharge tube, as previously reported, it was suggested that the formation of the deposit was due to the nature of the gradient of potential between the axis and the wall of the discharge tube. The radial electric force thus developed, was responsible for driving the positive ions of mercury formed by the discharge to distinct positions on the wall of the tube. It follows from this that the positions where the deposits of positive ions were formed would be other than those of the negative ions. In order to test this view experiments have been performed with the metals potassium and mercury for positive ions and non-metals sulphur and iodine for negative ions. It has been found that in the case of metals (positive ions) no deposit is formed underneath the electrodes and in the case of non-metals (negative ions) the deposit is formed underneath the electrodes. This confirms the correctness of the hypothesis. It has been further found out that other conditions being the same the distances between the deposits formed on either side of the electrodes decreases with the increase of atomic weight of the element.

45. Piezo-electric quartz oscillators coated with metallic films.

S. K. KULKARNI JATKAR, Bangalore.

A quartz crystal gave an oscillating frequency of 96185 cycles when mounted between two flat plates. The frequency changed to 94200 cycles when both sides were plated by silvering and copperplating as so to solder a lead directly to the top electrode. On replating only the top with a thinner layer the frequency changed to 95930 cycles. Another crystal which would not oscillate in the usual type of holder gave on sputtering with silver two nearby frequencies 49712 and 46157 cycles giving an audible beat of 3555 cycles. On replating by silvering and copperplating the crystal oscillates only at 48561 cycles. The relation between the thickness of the plating and the change in frequency of crystal oscillators is being studied.

46. The disappearance of hydrogen in high frequency electrodeless discharge.

N. B. BHATT, Bangalore.

A 2-meter magnetron oscillator has been used to excite the H.F. discharge in previously baked pyrex glass and fused silica tubes. The rate of disappearance of hydrogen is measured by a sensitive Pirani gauge. It is found that the disappearance is partly due to surface adsorption and partly due to formation of a condensible product. On passing the discharge through the condensible gas, the pressure increases and the gas emits a blue glow giving a band system in the visible part of the spectrum which was subsequently identified as the Angstrom Band System of CO. In some cases a condensible gas soluble in H_2O and giving strong alkaline reaction and Nessler's test was found. This gas is probably not SiH_4 as reported by E. Hiedemann (*Zeit. fur. Phys. Chem.*, A, 164, March 1933, p. 20).

The electrodeless discharge in SiH_4 itself decomposed the gas, immediately depositing a greenish-brown film of silicon on the wall of the tube.

The spectrum of the discharge either in pure H_2 or in SiH_4 gives the secondary spectrum of H_2 in the visible and in the near ultra-violet. Further spectroscopic investigations are in progress.

47. Carrier current telephony on phantom cable circuits.

S. P. CHAKRAVARTI, Bangalore.

For carrier current telephony over cables, an unloaded phantom circuit is superior to a loaded physical or phantom circuit on account of lower attenuation, lower cross-talk, absence of reflection loss, absence of a cut-off frequency and higher velocity of propagation. It is superior to an unloaded physical circuit because of lower attenuation and lower amplitude and phase distortion. The cross-talk can be minimized by operating at carrier frequencies as low as practicable having regard to modulation requirements. The author has attempted to develop a carrier telephone system on these lines. The circuit under study when measured with carrier of frequencies ranging from 3 to 9 kc/s gave a more or less uniform attenuation. Next, a one-way carrier channel (carrier frequency=6210~ and transmission band 6210–8300~) was successfully worked on the phantom circuit simultaneously with a voice-frequency channel on each of the physical circuits. Experiments for working a two-way channel (carrier frequencies of 6210 and 3000~ and transmission bands of 6210–8300 and 3000–5000~) simultaneously with three voice-frequency channels on the two physical and the phantom circuits are in progress.

48. Telegraphy in languages other than European.

N. S. Joshi, Poona.

The new code as introduced by the writer is a complete phonetic code that can be used for any language (not excluding European language) and is not meant for only the Sanskrit or the Sanskritic or the Dravidian languages. In any case it can be used for all languages prevalent in India, which is a great asset.

49. A new type of frequency and phase converter.

F. N. Mowdawalla *and* P. K. Kelkar, Bangalore.

A new type of converter for transforming three-phase alternating currents into single-phase or polyphase currents of sub-multiple frequency is described. It consists of an armature similar to a D.C. armature but also provided with slip rings through which three-phase supply is fed into it. The field system is laminated and may be designed for excitation with either single-phase or polyphase currents. The exciter is a direct-coupled A.C. generator of suitable capacity and having the same number of poles as the converter. When the machine is running at half synchronous speed the exciting windings carry half frequency currents. The machine remains locked into synchronism at this speed and single-phase output of half frequency can be obtained from commutator brushes placed 180 electrical degrees apart. In spite of the single-phase output the currents drawn from the mains are balanced. The power factor can be varied and maintained at unity under widely varying load conditions. Preliminary experiments indicate that the machine can work with high efficiency and there is no sparking at the commutator. Outputs of other sub-multiple frequencies can be obtained by suitably selecting the number of poles of the exciter, and polyphase outputs can be obtained by using a suitable number of brushes.

50. A Polyphase Shunt Commutator Motor.

B. W. Chobhe *and* J. J. Rudra, Bangalore.

The behaviour of the Schrage Motor was studied for various values of the angle between the axes of the secondary and regulator windings, with a view to predetermine the performance of the motor from no-load tests. It has been found that the equations generally used to determine the co-ordinates of the circles for the primary current do not hold good, particularly at sub-synchronous speeds. It is however suggested that this may be due to the magnetic saturation of the motor teeth, which is relatively higher at sub-synchronous than at hyper-synchronous speeds. If this effect of saturation is taken into account by assuming that the m.m.f. of the regulator winding has negligible effect on the leakage and the equations are then derived, it is shown that better agreement with experimental results is obtained.

51. Effect of a.c. wave form on the accuracy of ammeters.

P. R. PILLAI, Bangalore.

In this investigation, six 5 amp. instruments of the moving-iron type, one of the induction type, and one of the hot-wire type were experimented with. Seven waves of different shapes but the same r.m.s. value were employed. The r.m.s. value of the current (at 25 cycles) was maintained constant with a high degree of accuracy by the use of a vacuum-junction and a potentiometer. It is shown that, in the case of the moving-iron ammeter the effect of wave-form depends only on the maximum value of the wave and not on the nature of the distortion. It was found that in the repulsion type ammeter, as the flux density is very low, the error due to the change of wave-form is very small. In the attraction type instrument the effect of eddy currents in the moving-iron also comes into play and therefore on a distorted wave the meter reads less than on sine wave. With the sine wave currents the reading of the induction type instrument increases with frequency up to 50 cycles and decreases beyond that point. Consequently with distorted waves the meter reads higher than on sine wave due to the effect of the second and third harmonics. The hot-wire instrument was found to read accurately on all waves, as expected.

52. A new method of doubling the range of the reed type frequency meter.

L. M. CHAKRADEO, Bangalore.

The reed of a frequency meter receives an impulse once every half cycle. Consequently its natural frequency 'f' must be double the supply frequency 'n' to be measured. If it is required to respond to a frequency of $2n$ its exciting circuit should be so modified that it receives an impulse once every cycle. One method of achieving this is by polarizing the exciting electro-magnet but this method is handicapped by certain practical difficulties. In the new method described in the paper the exciting coils are connected to the a.c. supply through a half wave rectifier which cuts out the negative half wave of each cycle. Consequently the reed receives an impulse during each positive half wave, i.e. once in each cycle. As compared with the older methods, this method possesses the advantage of very easy control of the exciting current and therefore the amplitude of vibration can be maintained constant for widely varying supply voltages by regulating the filament current of the rectifying valve.

53. On the maximum size of an incompressible sphere in equilibrium.

N. R. SEN, Calcutta.

If incompressibility be defined by the constancy of proper mass then Schwarzschild's sphere is not incompressible. A modification of the condition of incompressibility in the light of this definition leads to equations which are not integrable in finite forms. A rough upper limit to the size of the sphere can, however, be easily obtained. The condition can be made stronger and even the exact limit can be obtained by some numerical calculations. It is found that the incompressible sphere of water of maximum size will have a 'radius' of 230 million kilometres. If the material of the sphere have the density 10^{12}, the order of the maximum density of matter, such as Milne considers the core of some stars to possess, then such a sphere of maximum size will have a 'radius' of only about 230 kilometres.

54. On the statistical divergence between certain species of Phytophthora.

P. C. Mahalanobis, Calcutta.

A generalized coefficient of statistical divergence (D^2) developed by the author has been used in this paper to study the relations between five known species and three unknown samples of Phytophthora, data for which were collected by Dr. McRae, Director of the Imperial Institute of Agriculture, Pusa.

55. Tables for testing the significance of linear regression.

S. S. Bose, Calcutta.

The problem of testing the significance of linear regression (or trend in the case of time-series) is one of frequent occurrence in Statistics and Economics. As the distribution of the linear regression coefficient is not normal, probable errors cannot be used with safety in the case of small samples. R. A. Fisher has given a method of testing linear regression by calculating the mean variance due to deviations from linear regression.

The present table which is based on Fisher's work has been constructed for two different levels of significance (five per cent. and one per cent.). With the help of the present table it is possible to test the significance of the regression-coefficient (for sample size from 3 to 30) without practically any additional calculations beyond those necessary for determining the coefficient itself.

56. On the application of orthogonal polynomials in problems of graduation.

K. C. Basak, Calcutta.

The ordinary Least Square Method of fitting a polynomial to a given series of data is very laborious. Various writers, Tchebychef, Gram, Jordan, Esscher, R. A. Fisher and others, have developed certain efficient methods by which (1) the labour in calculating the coefficients is very much reduced, (2) the degree of the graduating polynomial can be increased by stages in such a way that the addition of a subsequent term would not affect the previous terms, and (3) the residual variation can be reduced stage by stage. All the methods, suggested by the different writers, require the help of orthogonal polynomials, whose special property is that if $P_m(x)$ and $P_n(x)$ are two orthogonal polynomials of degree m and n then

$$\sum_{x=0}^{n-1} P_m(x)P_n(x)=0,\ m\neq n.$$

These polynomials can be brought under the general form :—

$$P_r(x)=f(r)\Delta^r\{x_{(r)}\,(x-n)_{(r)}\}$$

where $f(r)$ is a constant with respect to x and it can be given any arbitrary value we choose. The different polynomials, as suggested by different writers, arise out of different considerations made in choosing $f(r)$. The polynomial $P_r(x)$ can be expressed either as a factorial series or as a power series. Both have their respective advantages. Special properties of these polynomials reduce the labour in computing the necessary moments. Tables for the coefficients of the polynomials have been provided, which would make the work of polynomial graduation (at least up to the 5th degree) extremely simple.

57. The application of hyperspace geometry in the theory of multiple correlation.

RAJCHANDRA BOSE, Calcutta.

If there are n associated characters and a sample of N individuals is taken, then x_{ij} may represent the ith character for the jth individual. We may now take an N-dimensional space and in it take n-points x_i with co-ordinates $(x_{i1}, x_{i2} \ldots)$ where $i=1, 2, 3, \ldots$. Then the system of n-points so obtained completely represents the given data. It is found that the various constants in the theory of multiple correlation have all concrete geometrical interpretations. Most of the theorems, including inequalities between various correlation coefficients, are capable of simple geometrical proofs.

58. 'Cauchy's Problem in non-linear partial differential equations of Hyperbolic Type.'

M. R. SIDDIQI, Hyderabad.

Let $p(x)$ be an essentially positive function defined in the interval $0 \leq x \leq \pi$. We consider the equation

$$\frac{\partial}{\partial x}\left\{ p(x) \frac{\partial u}{\partial x} \right\} - \frac{\partial^2 u}{\partial t^2} = u^2,$$

for the boundary conditions:

$$u\ (x, t) = 0 \text{ for } x=0 \text{ and } x=\pi,$$

$$u\ (x, 0) = f_1(x), \frac{\partial u}{\partial t}\frac{(x, 0)}{} = f_2(x).$$

The functions $f_1(x)$, $f_2(x)$ can be expanded in a series of Sturm-Lionville Eigenfunctions.

With the help of a system of non-linear integral equations and by the method of successive approximations, we prove that for sufficiently small t, one and only one solution of the differential equation exists which satisfies the given conditions.

The equation is a generalized form of that considered by Herr Lichtenstein : *Crelle's Journal*: Vol. 158 (1927), and is based on a property of the Sturm-Lionville Eigenfunctions proved by the present writer: *Bulletin of the Academy of Science*, U.P., Vol. 3, (1933).

59. On conditions that certain algebraic integrals might be rational.

P. N. DAS GUPTA, Patna.

Gilham in *Journ. Lond. Math. Soc.*, Vol. 8, Pt. 2, No. 30, 136–141, discussed conditions of rationality of $\int \frac{f dx}{\phi^2}$ where ϕ and f are polynomials of degrees n and $2n-2$ respectively. The present paper treats of conditions of rationality of $\int \frac{q\,dx}{\phi^{r-1}}$ where ϕ and q are polynomials of degrees n and $nr+n-2$ respectively. Certain syzygies based on transvectant relations are worked out for special forms. The results are obtained by symbolical methods.

60. A reference chart for the apparent motion of the Sun and the planets.

B. K. Vaidya, Bangalore.

A simple and convenient method of representing the apparent motions of the Sun and the planets is provided by plotting on a system of co-ordinates the longitude or the right ascension of the body against the time of the year. When a combined chart for all the planets is prepared in this way, it shows at a glance all the planetary phenomena, such as: (i) the position of the planets in the sky at any time, (ii) the times of various conjunctions, (iii) the synodic periods, (iv) the stationary points, (v) the retrograde and the forward motions, and (vi) the times of the year when Mercury and Venus are morning and evening stars.

Such a chart for the year 1934 is shown.

61. The apparent distribution of stars in certain regions of the sky recently photographed at the Nizamiah Observatory.

T. P. Bhaskara Shastri, Hyderabad.

At the suggestion of the International Astronomical Union, the Nizamiah Observatory undertook a few years ago the catalogue for the 'Carte du Ciel' in the belt of the sky between Decl. +35° and +40°. The work of taking and measuring the photographs is very nearly complete and the first volume of measures of stars in this section is in the press. A continuous portion of the belt lies in the Milky Way, extending about seven or eight hours in Right Ascension, and the apparent distribution of stars in these regions presents some interesting features. The star density per square degree in each hour of R.A. is tabulated and discussed with reference to its galactic co-ordinates. The ratio of the number of stars in the galactic regions to those near the poles of the Milky Way (galactic condensation) is found to be 4·5, a number somewhat larger than the value given by Van Rhijn in G.P. 27 for the corresponding limiting magnitude (13·0) on the photographic scale.

62. On evaporation and its measurement.

S. Banerji *and* N. V. Kogekar, Poona.

In continuation of the work on the subject by S. K. Banerji and H. M. Wadia (*Memoirs of the India Meteorological Department*, Vol. XXV, part IX, 1932), further experiments were carried on by the authors at Poona mainly with the object of studying the behaviour of the layer next to the evaporating surface. For this purpose an evaporation tank (2′ × 2′ × 1½′) with the usual water channel all round was placed in a closed chamber, with an arrangement for varying the radiation by an electric heater with parabolic reflector. A large number of open-scale thermometers (dry and wet-bulb) were arranged with axial symmetry and with their bulbs at various heights above the water surface. Thermometers were also installed for recording water temperature; a black-bulb in vacuo was used for taking measurements of the radiation. An eye-reading evaporimeter was also observed at the same time. Starting with a known sample of air, observations were taken with (1) water temperature varying, air temperature remaining constant, (2) water temperature constant but air temperature varying, (3) both water and air temperatures varying. The observations indicate the existence of a layer of depth varying from 3 to 6 cm., according to the intensity of radiation and temperature of water, next to the evaporating surface with properties different from those of the layers above. These properties have been plotted and analyzed in the paper. Records have been taken of the air movements above the evaporating surface, by means of smoke lines. Some continuous records of evaporation in the open were also taken.

63. Variation of electric potential gradient at Bombay.

S. K. BANERJI *and* V. K. SHAH, Poona.

The diurnal variations of the potential gradient at Bombay for the different months and seasons based on the observations taken during the years 1929–31 have been discussed in this paper and compared with the corresponding variations at several stations over the world. The afternoon minimum is very well-marked at Bombay; it is more pronounced during the monsoon months than in other months and would thus appear to support a suggestion made by Whipple that it is dependent on meteorological factors. The type of variation at Bombay is the one generally found in tropics and lies between that at Tokyo and at Batavia. When the variation of the potential gradient is plotted in accordance with the natural classification of seasons at Bombay, namely, (1) December to March (sky clear), (2) April, May, October, and November (sky partially clouded), (3) June to September (sky fully clouded), it is noticed that the gradient has the mean value of about 145 V/M during the first period, it falls down to about 100 V/M during the second period and has the lowest value of about 85 V/M during the last period. This would agree with the observation that the cloud has in general a depressing effect on the potential gradient. The effect would appear on the average to be almost proportional to the amount of cloud in the sky.

64. Vertical currents in the lower atmosphere over Poona and their variation with the time of the day.

K. P. RAMAKRISHNAN *and* OTHERS, Poona.

With a view to study vertical currents in the lower atmosphere due to insolation and their variation with the time of the day some twenty pilot balloons with practically no free lift were released at heights of 0·5 to 2·5 km. between 8 A.M. to 6 P.M. on three clear days in the winter of 1930-31. The height time curves of the balloons disclosed the existence at these levels of both ascending and descending currents up to 8 *to* 10 *km./hr.* (or 5 to 6 m.p.h.). The currents are more marked in the afternoons of days when the general wind system is weak. They do not seem to depend for their existence on the contour of the land.

A picture of the diurnal variation in each 200 metre layer is shown in the form of a diagram. The standard deviations of the velocities and their north and east components are also worked out for each 200-metre layer.

65. The general circulation of the atmosphere over India and its neighbourhood.

K. R. RAMANATHAN *and* K. P. RAMAKRISHNAN, Poona.

Charts are drawn of mean stream lines and isodynamics in the upper atmosphere over India and neighbouring regions up to 8 km. from wind data obtained from pilot balloons and clouds. They show among other things :—

(1) The axes of deformation and singular points in the field of motion which determine the places of formation and travel of depressions.
(2) The manner in which the monsoon circulation is built up.
(3) The characteristics of the quasi-permanent anticyclone which exists over the Deccan in winter and early summer.

66. Far eastern origin of a few cyclonic storms in the Bay of Bengal.

V. Doraiswamy Iyer, Poona.

In the early days of Indian Meteorology it was considered that all storms in the Bay of Bengal originated in the Bay itself. The Port Blair cyclone of November, 1891, and the Chittagong cyclone of October, 1897, which entered the Bay from the east led to a modification of this view. The Revd. Father Jose Algue, S.J., has shown that the above cyclones were connected with typhoons in the China Sea. The author in the course of a systematic search has found many more instances of typhoons from the China Sea reforming into depressions or storms in the Bay of Bengal after travelling over the Indo-Chinese Peninsula. Two particular instances have already been published. The years from 1884 to 1930 have been examined and a short account of each of the typhoons which have affected Indian weather compiled; the paths of those which have reformed into depressions or storms determined. The main points brought out are that such typhoons have been rare in the months December to June, and that many have come across in the months July to November. The proportion that has redeveloped into storms is greatest in October and November, and most of these are found to be storms of small extent.

67. Types of temperature transition between the troposphere and stratosphere and their significance.

K. R. Ramanathan *and* K. P. Ramakrishnan, Poona.

An analysis is made of the different types of transition between the troposphere and the stratosphere met with in sounding balloon records. An explanation is offered of the double type of transition frequently noticed in the records from North India during winter and early hot season as being due to the tendency of the tropopause to get folded up in latitudes where its height varies rapidly with latitude.

68. Characteristics of spells of continuous and heavy rainfall and of intermittent and light rainfall at Khandala during the monsoon of 1933.

K. J. Kabraji, Poona.

From self-recording raingauge charts obtained at Khandala continuously from 14th June to 30th September, 1933 (except for accidental interruptions in the records), the amounts collected in each hour were tabulated. This table of 24-hourly values for each of the 109 days of the above period was divided up into spells of (1) continuous and/or heavy rain, (2) intermittent and/or light rain, and (3) no rain (after adopting suitable criteria for continuity and for intensity in each type of spell) and the amounts in each of the 24 hours of each spell were aggregated. The main interest of the results consists in their shewing up of marked maxima during almost the same hours in most successive spells, but with a gradual change in their times to later hours as the monsoon advances and till the series of maxima disappear.

There appear to be six such maxima in the early part of the monsoon, and some four are still discernible in the latter part, till the introduction of precipitation of the thunderstorm type begins completely to mask the afternoon maxima and the forenoon maxima disappear with the precipitation in the forenoons becoming very scanty.

The hourly aggregates of each spell divided by the number of hours (i.e. days) (*a*) in which precipitation occurred and (*b*) in which precipitation of over 10 cents occurred in it also yield some interesting results.

An explanation is being sought and all previous available records are being examined.

69. On the higher temperatures of rain than of air at Khandala on the Western Ghauts.

K. J. Kabraji, Poona.

Observations during August, 1932, and July, August and September, 1933, shewed rain temperatures to be higher than those of the air at the observatory level (c'a 1,800 ft. a.m.s.l.), by, on the average, about 0·5°C. in July to about 0·1°C. in September, individual values of the difference reaching a little over 1·0°C. in heavy showers. When accompanied by fog, i.e. when the monsoon clouds are low enough for the observations to be well within them, the differences are much smaller, averaging about 0·1°C. in July and August, and less in September. With the gradual introduction of and changing over to precipitation of the thunderstorm type in September, frequent instances of the rain being colder than the air also occur, and account for the low average difference in that month.

An interpretation based on the different degrees of dynamical cooling undergone by the monsoon clouds, the air beneath them in which condensation takes place on ascent and the still lower air which reaches Khandala without condensation of its moisture, is adduced.

70. Further studies on the light from the night sky.

K. R. Ramanathan *and* J. V. Karandikar, Poona.

The results that have been obtained in 1933 regarding the spectrum of the night sky and of the zodiacal light and of the variation during night of the intensity of the light after filtration through green and blue screens are summarized.

71. Transmission of light through clouds.

N. N. Bhagwat *and* G. R. Paranjpe, Bombay.

Houghton (*Phys. Rev.*, No. 1, Vol. 38, 1931) has shown that the coefficient of light transmitted through a cloud depends on the number and size of the cloud particles per c.c.

It is possible now to prepare clouds of various sizes of drops and at different temperatures. The radius of the droplet is estimated by observations of the corona rings and the intensity of the transmitted light is measured, in different colours, using a photo-cell.

72. A study of the intensity of floods in the Sone River with reference to the rainfall and run-off.

S. K. Ghose, Arrah.

In this paper an attempt has been made to collect all available data regarding floods in the Sone River, in relation to the rainfall and run-off in the catchment. A remarkable periodicity in the floods has been investigated and certain formulæ derived empirically. A suggestion for preventing future floods has been given.

73. Supersonic velocity in gases and vapours.

S. K. KULKARNI JATKAR, Bangalore.

Using piezo-electric quartz oscillators whose frequencies were accurately determined by a two-stage stepdown multivibrator, the supersonic velocity in vapours at 97·1° was measured in a tube of 5·5 mm. diameter. The following values of velocity (given in metres per second) were obtained at 50, 96, and 127 kilocycles and were independent of frequency. Air 384·8, methyl alcohol 335·1, ethyl alcohol 269·7, ethyl ether 206·7, benzene 202·1, cyclohexane 191·3, methylene chloride 204·9, chloroform 171·0, carbon tetrachloride 145·4, ethylene chloride 181·1, acetone 238·6, isopropyl alcohol 255·2, ethyl acetate 188·9. The velocities in carbon dioxide and carbon disulphide are 296 and 219 at 50 kilocycles. No measurements could be made with these substances at higher frequencies owing to considerable absorption.

74. The effect of soft pedal on the vibrations of the Pianoforte sound-board.

L. D. MAHAJAN, Patiala.

The vibrations of the Pianoforte sound-board, when the soft pedal is pressed, are photographed, and analyzed up to twelve higher harmonics, with the mechanical method of Hawley O. Taylor [*Phys. Rev.*, 6, 303 (1915)]. The interesting results are deduced, showing the effect of the soft pedal on the vibrations.

75. Action of light on the surface tension of soap solutions.

L. D. MAHAJAN, Patiala.

The action of light on the surface tension of various soap solutions (Mahajan Effect) is studied. It is found that the light decreases the surface tension of the soap solutions, but the decrease in surface tension depends upon the kind of soap used, and the concentration of that in the solution. The action is general, and is not restricted to the Boys's soap solutions only.

76. Formation of liquid drops on the same liquid surface, at very high hills.

L. D. MAHAJAN, Patiala.

The experiments on the formation of liquid drops on the same liquid surface were performed last year (September, 1932), at the Rohtank Pass (at about 14,000 ft. above the sea-level) in the Himalaya Hills (Kulu Valley). The formation of water drops on the water surface of the Rishi Bias spring, the source of river Bias, was studied. The various mehods of formation were employed, and it was observed that :—

(i) The formation of the primary drops was impossible at such height.

(ii) The formation of the secondary drops was difficult. The life of the secondary drops, if any formed, was hardly a second.

Similar experiments were performed this year again (September, 1933), at the Tiryun-Ilaqakhud (snow line, at about 15,000 ft. above the sea-level) and the similar results (the above-mentioned) are obtained, again.

These results confirm my previous work on 'the effect of low pressure on the liquid drops on the same liquid surface' (*Current Science*, Vol. 1, No. 6, pp. 162-163, Dec. 1932).

77. Impact of drops on plane surfaces.

S. B. L. MATHUR, Bombay.

Coste and Blacktin have recently studied the interaction between soot films and oil. Very beautiful patterns are obtained when carefully posed drops are allowed to fall upon a horizontal plate, on which an even coating of soot is deposited. The work has been extended and some interesting facts collected.

78. Viscosity of molten metals.

H. B. MOHANTY, Cuttack.

Taking the viscosity values of molten tin, which are available over a wide range of temperature extending from 250°C. to 800°C., it has been shown that the viscosity of molten tin can be accurately represented by the formula $\log \eta = A + B/T - \theta$; the accuracy being about 0·5%. The latent heat of tin derived from the above formula by Herzog and Kudar's method is expected to be in better agreement with the experimental values found out by thermal and calorimetric methods than the value derived by Awebery by plotting the logarithm of viscosity against the inverse of absolute temperature. The viscosity of mercury has also been investigated but the agreement in this case is not so good as in the case of tin. Doubt is thrown on the viscosity values of mercury and they seem to require revision.

79. Viscosity of liquids.

H. B. MOHANTY, Cuttack.

It has been shown that the formula put forward by Andrade, connecting the viscosity of a liquid with its temperature, can be easily derived from Porter's original relationship $\log \phi = m \log p + c$. The same formula was also put forward by Sir C. V. Raman as early as 1923 although on semi-empirical grounds. The formula has been tested in case of a large number of liquids and is found to be in good agreement with the experimental values. Black has objected to the formula on the ground that it does not hold good in case of certain mineral oils. It has been shown by the author that, instead of using the simple formula for ordinary liquids, if we use a slightly modified formula which holds good for associated liquids perfectly satisfactory agreement can also be obtained with Black's oils. Over and above this the viscosities of seven other lubricating oils like Machine oil, Valvol, Vacuum oil, etc. and that of oil of terpentine are found to be in good agreement with the formula suggested, and the viscosities of vegetable oils are under investigation.

80. Viscosity of solutions.

B. PRASAD *and* H. B. MOHANTY, Cuttack.

Viscosity of water is usually represented by a four-constant formula. The authors have shown that the viscosity of water can be well represented by the three-constant formula $\log \eta = A + B/(T - \theta)$. Further it has been suggested that the forces which bind the solvent and the solute molecules together are of the same nature as that which exist between the constituents of an associated molecule. The suggestion has been tested by showing that the viscosity of solutions—both electrolytes and non-electrolytes—like that of common salt and sugar, can be well represented by a formula of the above type.

81. The temperature variation of the viscosities of aqueous solutions of strong electrolytes.

E. B. RAJDERKAR *and* G. R. PARANJPE, Bombay.

A viscometer, suitable for relative measurements, has been evolved, giving the kinetic energy correction negligible.

An air thermostat has been constructed with improvements in the heating arrangements and air circulation.

The coefficients of viscosity of aqueous solutions of the chlorides of lithium, sodium, potassium, rubidium, calcium, strontium and barium, and ammonium chloride have been determined between 30° and 75°C. for normalities N, $N/2$, $N/4$.

An account is taken of the present positions of the theories of viscosity of electrolytic solutions and as far as possible, the results obtained have been discussed in the light of these theories.

82. Photo-electrostatically controlled pendulum.

C. CHANDRASEKHARIAH, Bangalore.

The imparting of an impulse to a pendulum by mechanical means involves some uncertainty as to the magnitude of the impulse on account of the wearing of the surfaces of contact and friction. To overcome this difficulty, the impulse is sought to be delivered by an electrostatic arrangement.

The pendulum carries at the bottom a brass comb of which the teeth pass freely through another similar comb rigidly fixed to the base. Just above the comb is a narrow slit which permits light to pass through and fall on a photo-electric cell. The slit permits the light from the lamp to fall on the cell when the pendulum is passing through its zero position. Consequently at that instant an electric pulse is generated which, by suitable arrangement of the electric circuit, produces an instantaneous electro-static field between the two combs, this gives rise to the driving impulse which is imparted to the pendulum without mechanical contact. As the pendulum is intended to work in vacuum and as the impulse is delivered twice in each oscillation its magnitude need be quite small and the interference with the free swing of the pendulum is thus reduced to a minimum.

The performance of an experimental model constructed on the above principles is under investigation.

83. Influence of temperature on the photo-expansion in Iodine.

T. S. NARAYAN, Bangalore.

The influence of temperature on the photo-expansion of iodine was studied. An all-glass manometer sensitive to 0·1 mm. was used to measure the pressure changes. The photo-expansion was found to diminish with rise in temperature. At 200° the expansion recorded was 0·7 mm. and at 320° the expansion was 0·45 mm. This result throws light on the recombination of atoms and the influence of walls on chemical processes.

It was found that iodine vapour reacts with soda glass and resistance glass in a vacuum above 350° with the formation of SiI_4, an observation not made by Firth in his experiments on the permeability of glass walls to iodine vapour. In consequence erratic pressure changes were recorded in the vapour pressure curve of iodine.

84. Fluctuation in a degenerate gas.

M. Ghosh, Calcutta.

A complete theory of the fluctuation in a degenerate gas is developed in the same manner as before. The relation between the different partial fluctuation in this case are $(\overline{\delta^2 p})_T=(\delta^2 V)_T \; 25(1 \pm 8c/z^2)/9 \; (10c/z^2)^2(\overline{\delta^2 T})_p =25(\overline{8^2 v})_p \; (1 \pm 8c/z^2)/9$ and $(10c/z^2)^2 \; (\overline{\delta^2 T})_v=(\overline{\delta^2 E})_v=(\overline{\delta^2 p})_v$ where $z=(3N/4\pi v)^{\frac{2}{3}} \; h^2/(2mkT)^2$, $c=\pi^2/6$ (Bose)$=\pi^2/12$ (Fermi). The values of the density fluctuation at constant temperature $(\delta^2 v)_T$ and every fluctuation at constant volume $(\overline{\delta^2 E})_v$ are $(1 \mp 6c/z^2)/2N$ and $4(1 \mp 25c/z^2)/21N$ respectively. With the help of these values and the above partial relations one readily gets $(\delta^2 T)_v=\frac{4}{21N}\left(\frac{z^2}{10c}\right)^2 (1 \mp 25c/z^2)$ and $(\overline{8^2 p})=1{\cdot}58 \; (1 \mp 1{\cdot}13c/z^2)/N$.

85. Existence of the free energy of Bose-Einstein and Fermi cell.

M. Ghosh, Calcutta.

In deriving the distribution function of Bose-Einstein and Fermi statistics by generalizing Gibb's method, Kar and Mazumder (*z. f. Phys.* 55, pp. 546–554, 1929) introduced a new class of free energy ψ_s per s type cell, over and above the free energy ψ per molecule. In this paper is discussed how free energy per cell plays an important part in the new statistics. Now $\sum_s A_s\psi_s=\Psi_2$ the total free energy of all the cells; 'As' being the total number of 's' type cells. As the extension of the classical statistics is ultimately due to the structure of the phase space Ψ_2 may be taken as the additional free energy of N molecules arising out of the cells; so the total free energy is $\Psi=\Psi_1+\Psi_2$ where $\Psi_1=N\psi$ the classical value of the total free energy. Now classical statistics gives

$$-\partial\Psi_1/\partial V=P_{(\mathrm{mol})}=NkT/V$$

and as

$$A_s\psi_s=\pm kTln\left(1 \mp e^{\frac{\psi-u_s}{kT}}\right)$$

$$\text{so } -\partial\Psi_2/\partial V=P_{(\mathrm{cell})}=\frac{NkT}{V}\left\{F_{\frac{3}{2}}(\psi kT)/F_{\frac{1}{2}}(\psi/kT)-1\right\}.$$

The total pressure

$$P=P_{(\mathrm{mol})}+P_{(\mathrm{cell})}=\frac{NkT}{V}\,\frac{F_{\frac{3}{2}}(\psi/kT)}{F_{\frac{1}{2}}(\psi/kT)}$$

which is the well-known equation of state in the new statistics. In the case of radiation $As=8\pi V\nu^2{}_s d\nu_s/c^3$ and $u_s=h\nu_s$ and $\Psi_1=0$ so we get

$$P_{(\mathrm{Rad})}=-\partial\Psi_2/\partial V=8\frac{\pi kT}{c^3}\,(kT)^3.\,\frac{1}{3}\int\frac{x^3dx}{e^x-1}=\epsilon/8 \text{ (Plank).}$$

As these deductions are based upon the conception of the free energy of the cells, its existence is strongly supported.

86. Correspondence between the classical and quantum theory of energy dispersion.

M. Ghosh, Calcutta.

The expression for the dispersion of energy of molecules is from definition $N(\overline{u^2}-\bar{u}^2)$ where u is the energy per molecule. In the case of classical statistics the above expression is reducible to $N\theta^2\delta\bar{u}/\delta\theta$ where $\theta=kT$. But it is different in the case of quantum statistics. The mean energy

$$\bar{u}=\int_0^\infty g_s u_s e\,\frac{\psi-u_s}{\theta}\,d\tau \bigg/ \int_0^\infty g_s e\,\frac{\psi-u_s}{\theta}\,d\tau$$

where

$$g_s=\left(1\mp e\,\frac{\psi-u_s}{\theta}\right)^{-1}$$

and similarly for $\overline{u^2}$. From the above we easily get

$$N\,(\overline{u^2}-\bar{u}^2)=N\theta^2\partial\bar{u}/\partial\theta\mp\tfrac{3}{2}N\theta^2\,.\,\frac{S}{8}\,\frac{N}{V}\,\frac{h^3}{(4\pi m\theta)^{\frac{3}{2}}}\,.$$

This shows that one is not justified in deriving quantum dispersion by simply substituting the quantum values of $\bar{u}$, $\bar{p}$, etc., in the classical expression for dispersion.

87. Application of the new statistics to the theory of the spontaneous fluctuation.

M. Ghosh, Calcutta.

The theory of spontaneous fluctuation from the point of view of classical statistics has been given by several workers. In this paper the author has generalized the classical partial relations of Kar (*Phys. Rev.*, 21, p. 672, 1923) with the help of quantum statistics (Bose, Einstein and Fermi). They are in their usual notations $(\overline{\delta^2 p})_T=(\overline{\delta^2 V})_T(1\mp y)$, $(\overline{\delta^2 T})_p=(\overline{\delta^2 V})_p\,(1\mp 5y/2)$, $(\overline{\delta^2 T})_V=(\overline{\delta^2 p})_V\,(1\mp 3y/2)$, $(\overline{\delta^2 E})_V=(\overline{\delta^2 p})_V$ and $(\overline{\delta^2 E})_T=(\overline{\delta^2 V})_T\,.\,\frac{y^2}{4}$ where $y=Nh^3/V(4\pi mkT)^{\frac{3}{2}}$ and the upper sign is for Bose-Einstein statistics and lower for Fermi. In order to get any other fluctuation one must know, in addition to the above relations, at least two partial fluctuations, the values derived from the new statistics are

$$(\overline{\delta^2 E})_V=\frac{2}{3N}\,(1\pm 5y/2) \text{ and } (\overline{\delta^2 V})_T=\frac{1}{N}\,(1\pm{\cdot}647y).$$

From the above equations one readily gets

$$(\overline{\delta^2 T})_V=\frac{2}{3N}\,(1\mp{\cdot}875y),\ (\delta^2 p)=\frac{5}{3N}\,(1\pm{\cdot}039y).$$

It is noteworthy that neglecting higher correction y one gets the well-known relation of Kar.

88. Transport phenomena in quantum statistics.

A. Ganguli *and* P. Mitra, Chandernagore.

Transport problems have been studied by using the new Quantum Statistics and following Maxwell-Chapman method. It is interesting to note that the general adiabatic law $p\rho^{-\frac{2}{3}}$=const. is valid for the degenerate case as well. Expressions for viscosity, conductivity, and diffusion have been obtained by considering the inverse fifth power law. The method has been extended to the case of electrons obeying inverse square law by following procedures due to Chapman and Perisco. It may be noted that the expression for viscosity $k=p/n\phi_1$, where n is the number per unit volume and ϕ_1 a constant, is the same for both degenerate and the classical cases. The expressions for conductivity ϑ=const. kcv and diffusion D=const. p/n^2 are also similar to those for the classical case. Conductivity due to free electrons is zero in the first approximation in the degenerate state. Stellar application of these results is also indicated.

89. Influence of temperatures and solvent on the electrical moment of ethylene bromide.

M. A. Govinda Rau *and* B. N. Narayanaswamy, Bangalore.

The moment of ethylene bromide has been measured in the four solvents—benzene, carbon tetrachloride, cyclohexane, and toluene—for the four temperature 10, 20, 30, and 40°, with the improved apparatus and methods of calculation previously reported. From these values, following the method of Higasi (*Proc. Imp. Academy*, Tokyo, *8*, 482, 1932), the potential energy between the polar groups in the molecule has been calculated for each solvent. This potential energy appears to vary inversely as the dielectric constant of the solvent.

It is interesting to observe that the moment is definitely a function of the nature of the solvent.

90. The dipole moment of nitrobenzene in different solvents.

M. A. Govinda Rau *and* B. N. Narayanaswamy, Bangalore.

The moment of nitrobenzene has been measured in the four solvents—benzene, carbon tetrachloride, cyclohexane, and normal hexane—and found to depend upon the nature of the solvent, being highest in cyclohexane and least in benzene. At 20° the moments are 4·00, 4·04, 4·12, and 4·10 respectively.

In every case the polarization at infinite dilution does not obey Debye's law over the range of temperatures studied, there being a definite though small increase of moment with temperature.

The relation between the degree of association at different concentrations and temperatures and the nature of the solvent are discussed.

91. Variation of dielectric constant with frequency.

P. Y. Deshpande *and* G. R. Paranjpe, Bombay.

A determination of the dielectric constants of a series of pure vegetable oils and fatty acids is being attempted within the range of 15 to 200 metre waves. The method employed is the measurement of the capacity of a simple condenser immersed in the liquid.

92. Note on the effect of magnetic field on the dielectric constant of gases.

S. Datta *and* K. G. Mazumdar, Calcutta.

In a previous communication (vide *Proceedings Indian Science Congress*, Madras, 1929) it was reported that by using a very sensitive heterodyne absorption method as proposed by Gunn a small change was detected in the dielectric constant of Carbon-dioxide by a magnetic field. In view of the importance of this question from theoretical standpoint—inasmuch as the calculations based on wave-mechanics by Van Vleck and others predicted results contradictory to those based on quantum mechanics by Hettner and others—and in view of the uncertainties involved in heterodyne absorption methods based on the measurement of change in the anode current in the receiving circuit, it was thought desirable to repeat the experiment by using an equally sensitive heterodyne beat method, a quartz oscillator being used in one of the oscillatory circuit to keep the frequency constant. This has yielded negative value not only in the case of Carbon-dioxide about whose orientations in the magnetic field there is some controversy but also in the case of such paramagnetic gases as Nitric Oxide and Nitrogen Peroxide which have definite orientations. The present experiments thus decide the question in favour of the theory based on wave-mechanics.

93. The effect of superimposed magnetic fields on the dielectric strength of solids.

N. V. NARAYANASWAMI *and* F. N. MOWDAWALLA, Bangalore.

In a previous paper (*Proc. Indian Science Congress*, 1933, p. 95, Paper No. 5) the authors published some results relating to the effect of superimposed magnetic fields on the b.d.v. of air and insulating oil. It was found that the b.d.v. was unaffected by magnetic fields up to 10,000 gauss both transverse and longitudinal with respect to the dielectric field. Investigations have been continued on solid insulating materials like presspahn, manilla paper, pressboard and glass with D.C. magnetic fields up to 18,000 gauss. A large number of tests indicate that the magnetic field produces a small, though definite, change in the dielectric strength. In all samples a transverse field produced an increase of b.d.v. while the effect of a longitudinal field was to increase the b.d.v. in some cases and decrease it in others, the change in all cases ranging from 1 to 6%. These results do not agree in magnitude with those published by Monkhouse (*Proc. Phys. Soc.*, 1928, **41**, 83) who working with similar materials at much lower magnetic intensities has reported very large changes in dielectric strength.

94. The effect of superimposed magnetic fields on dielectric power factor.

N. V. NARAYANASWAMI *and* F. N. MOWDAWALLA, Bangalore.

The effect of a superimposed magnetic field on the capacity and power factor (or loss angle) of mica, glass, presspahn, pressboard, kraft paper and manilla paper was investigated with the help of a high voltage Schering Bridge. The condenser in which the materials under test were used as the dielectrics was made up of two parallel 1″-dia. discs mounted on mica plates and was placed between the poles of an electromagnet giving D.C. field intensities up to 18,000 gauss. The bridge measurements for both capacity and power factor of the samples were made at 50 cycles alternately with and without magnetic field at electrical stresses ranging from 50 to 300 volts per mil. The magnetic and dielectric fields were in all cases co-axial.

The results indicate that the capacity and power factor of glass and mica are unaffected by the magnetic field. In the other samples the capacity undergoes only a very slight change while there is a change in the power factor varying from 5 to 10% depending on the sample. In manilla paper and pressboard there was an increase, while in kraft paper and presspahn there was a decrease in power factor when the magnetic field was applied. It was also observed that within the range of dielectric stress applied there was very little variation in the change of power factor indicating that the entire change takes place at a low value of the electric stress.

Further work is in progress with regard to other materials and the effect produced when the magnetic field is transverse with respect to the dielectric field.

95. The effect of impurities on the dielectric strength of transil oil.

B. S. Ramaswami, N. V. Narayanaswami, *and* F. N. Mowdawalla, Bangalore.

The effect of certain added impurities like moisture, cotton and pressboard fibres, and carbon on the b.d.v. of insulating oils has been studied by the British Electrical and Allied Industries Research Association and a report has been published (E.R.A. Report No. E/T. 37, *Journ. I.E.E.*, 1929, **67**, 750). The authors have investigated the effect of other impurities like alcohol and shellac which are usually present in oils contained in electrical apparatus, and also the effect of paraffin wax. Experiments were carried out on samples of dry oil having an initial b.d.v. of about 70 KV. R.M.S. and also those containing varying degrees of moisture, and the impurities were added gradually to these samples. The tests were made with 25-cycle alternating current with the standard BSS test electrodes. The results obtained indicate that, with dry oil, the different impurities produce different amounts of lowering of the b.d.v. and this lowering increases progressively with the addition of the impurity up to a certain point beyond which further addition produces no effect. In no case did the b.d.v. fall below 36 KV. With moist oils, the lowering is due to the combined effect of moisture and impurity, and with successive breakdowns the final asymptotic value is reached only after a very large number of shots, during which moisture is gradually removed in accordance with results published by the authors (*Proceedings Indian Science Congress*, 1933, p. 95, Paper No. 4).

96. The refractive index and dispersion of gases.

K. L. Ramaswamy *and* H. E. Watson, Bangalore.

The dispersions of mono- and disilane, sulphur hexafluoride, silicon tetrafluoride, ethane, ethylene, propane, propylene and cyanogen have been measured with a Rayleigh interferometer. The refractive indices for the lines 6438, 5460, 5086, 4800, 4358 Å have been measured and the dispersions calculated from these results.

Simultaneous determinations of the dielectric coefficients of these gases have been made and the results compared.

97. New method for the determination of the mean fibre-length and the fibre-weight per inch of cotton.

Nazir Ahmad *and* C. Nanjundayah, Bombay.

The prevalent methods for the determination of the mean fibre-length and the mean fibre-weight per inch of cotton are capable of giving, in the hands of a trained worker, fairly accurate results, but suffer from the serious defect that they absorb a great deal of time. This restricts their use to technological laboratories and prevents trade and industry from making free use of them. The method described in this paper is based on a new principle and is capable of giving accurate values of the two properties mentioned above in a single operation without sacrificing accuracy, thereby effecting a considerable saving in time. An apparatus has been designed embodying the new methods and details of this apparatus together with the results of tests on representative cottons are given.

98. German State Law on Thermometry and the arbitrariness of our temperature measurement.

SATYENDRA RAY, Lucknow.

The German State Law, *theoretically*, is identical with the thermodynamic scale. *Practically* a range of temperatures from -193° to 4,300 is claimed to be definable with any degree of accuracy cognizable by the State. The region is divided into four sub-divisions. The air thermometer is nowhere used.

In the first two ranges the same thermometric substance—a platinum wire—is used with two *different* formulæ. They clearly give a mathematical 'discontinuity' corresponding to the melting point of ice.

In each of these formulæ the constants are determined with the use of a number of stationary temperatures with 'pure' substances. This is an argument in a circle, wherein the chemist may be determining the purity of his substance by physical constants and the physicist may be depending on the constants of a stuff supplied to him by a chemist.

The third region is measured by a thermo-element. Here in the passage from the second to the third region a linkage by interpolation is established by determining the stationary temperatures according to the method of the second region, as should be done. The lack of this interlinking between the first and the second regions, as well as between the third and the fourth, becomes however all the more serious.

In the fourth region only one constant is involved.

It thus looks very much as if to the physicist (1) a mathematician supplies a function and (2) the chemist supplies specimens of matter, and with the help of the two he proceeds in an arbitrary fashion to settle a scheme of measurement of what he calls 'temperature'.

99. The enigma of the Absolute Zero.

SATYENDRA RAY, Lucknow.

There is *an* Absolute Zero associated with each thermometric substance for which a formula

$$v_t = v_0 \cdot (1 + \alpha t) \qquad .. \qquad .. \quad (1)$$

is assumed. *The formula itself leads to Charles' Law.* Compare the formula used by Preston for making the exposed column error correction with a mercury in glass thermometer.

Now the same argument which gives us −273 as the Absolute Zero in Matriculation text-books will obviously give us −5550 as the Absolute Zero on the mercury scale; while measured on a silica solid rod the Absolute Zero becomes −2000000. Which of these are we to choose and why ?

The mistake evidently lies in making the assumption (1). If instead of the 'zero coefficient' being assumed constant, the '*true* coefficient' is assumed constant, the formula (1) takes the form

$$v_t = v_0 e^{-\alpha t}$$

which makes the Absolute Zero equal to minus *Infinity* for *every* thermometric substance, and establishes easily the principle of 'Unerreichbarkeit des absoluten Nullpunktes' of Nernst.

100. An implication of our definition of temperature interval.

SATYENDRA RAY, Lucknow.

In the definition that increase of length is proportional to the increase of temperature (or its analogue referred to surface area or volume), we are making an assumption that is inconsistent. If a table is prepared in which from zero length, surface and volume, the increase, say, per

10^{-6} cm. in length is given then it may be seen that even with the same thermometric substance, the intervals as read off in the three systems are at variance with one another. Only the first interval is identical. The error lies obviously in assuming that when from zero volume the volume springs to 1, the interval is the same as when it springs from volume 1000 to 1001. In the first case the final volume is infinite times the initial volume, in the second case it is only 0·1%.

Stated symbolically

$$dT \neq k \,.\, dv \text{ but } dT = k \,.\left(\frac{1}{v}\right).\, dv.$$

With small values of coefficient and far from absolute zero we would get fairly good agreement. Of course for low temperatures we shall still get discrepancies. Perhaps that is why the German State Law does not vouch for temperature measurements below as high a temperature as −193°C.

101. The Second Law of Thermodynamics as the equivalence of every form of matter with an ideal gas.

SATYENDRA RAY, Lucknow.

The proposition that the Thermodynamical Absolute Scale is identical with the Absolute Gas Scale is proved by a *reductio ad absurdum*. It is presumed that the efficiency of the two engines describing a Carnot's Reversible Cycle is the same. As the heat is absorbed in this cycle only at one fixed temperature and given out at another, we can make the heats absolutely equal to one another by the choice of proper amount of the working stuff (Clausius's Method). Therefore, thermodynamically, that amount of the working stuff is equivalent to a certain amount of Ideal Gas in all respects. In the *reductio ad absurdum* the fallacy may be *here*, rather than in the assumption that the efficiency is the same, which leads us to the enigmatic position that the Absolute Zero is identical with 'the Absolute Zero on the Ideal Gas Dilatational Thermometer', and not on the Mercury or Silica ones.

102. On an engineering difficulty in the proof of the Second Law of Thermodynamics.

SATYENDRA RAY, Lucknow.

In coupling a supposed more efficient engine running direct with another less efficient running reverse, we, entirely in imagination, *quantise* 'work', and strike a bank balance after imaginary transaction after each cycle, without caring for the details of the transactions. We assume we have the work W from one engine and spend an amount W' out of it in the other engine and are left with a balance $W - W'$ after one cycle.

The cycle of thermodynamics is a periodic variation of the state of a quantity of matter, the period being *infinity*. When instead of waiting for the period being over, to strike the bank balance, we follow the intake of heat by one engine and the intake of the 'work' by the other, the author found that, *even with two Ideal Gas engines*, the phases of the change of state could not be made to agree. It therefore constitutes a most serious difficulty in the dogma of the Second Law of Thermodynamics.

103. The solid-gas,—a criticism of the definition of entropy as disorderliness.

SATYENDRA RAY, Lucknow.

By the Solid-Gas the author means a model in which every gas particle has the same velocity for all time so that it is a gas; while at the same time each particle retains its position and there is no diffusion of particles from one region to another, so that it is like a Bragg's crystal at the same time.

Imagine a cubical room divided into cubical cells by a series of equidistant partitions parallel to the walls. In each cell locate three particles moving parallel to co-ordinate axes, the lines of motion not passing exactly through the centre but slightly shifted from it to avoid collisions within the cell. The line of motion in cells in one row are to be one and continuous and the direction of motion in contiguous cells to be opposite. The phase of motion of two opposite velocities is adjusted so that collisions take place at the partition. The particles then will maintain their position and we have a case of perfectly ordered motion maintained for infinite time.

Now to study the passage of 'perfect order' into 'perfect chaos', have a transom window in one cell, at the centre of which the impact of a particle in the cell takes place. Post a 'Boltzmann's Imp' to sharply turn the transom window just once through a very, very small angle in the interval after an impact is over and before the next one occurs, the tilt being so adjusted as to avoid collision with the adjacent particle and to produce collision with a particle in another line near the opposite wall.

The perfect order will go gradually. The order in the line itself will be restored by the space lattice increasing by a small amount, but each stray particle will knock out, with time, more and more of the particles from the other cells, and send them in directions no longer parallel to the co-ordinate axes and chaos will set in.

It is quite clear that in this *change* from 'Perfect Order' to 'Perfect Chaos' no change in either (1) temperature, (2) pressure, or (3) heat contents shall have taken place. Therefore no change in Entropy will occur according to the definition $d\phi = dQ/T$, inasmuch as dQ is zero and T is constant.

104. On the genesis of Boltzmann's Definition of entropy.

SATYENDRA RAY, Lucknow.

The thermodynamical result that the entropy of the world system is tending to infinity, combined with the tendency of the disturbed solid-gas to pass into infinite disorderliness, suggests associationship between entropy and disorderliness.

A direct relation like

$$\phi = kW_P$$

Boltzmann saw would not work, where by W we mean the probability of a state corresponding to the state P in the Indicator Diagram. The difficulty lay in the *additive* law of entropies which thermodynamics gives us, viz.:

$$M\phi = m_1\phi_1 + m_2\phi_2 + m_3\phi_3 + m_4\phi_4 \dots.$$

This clashes with the law of products for the probability of the simultaneous existence of two states P and Q, which would make simultaneous existence of the states P and Q for a system given by

$$\phi = k \,.\, W_P \,.\, W_Q.$$

Analogously to the conversion of musical intervals into logarithmic cents [which makes the law of products for the physical intervals (n_1/n_2) into a law of summation, which to the musical ear the intervals obey physiologically]. Boltzmann therefore identifies Entropy with the *Logarithm* of the Probability of the State rather than the state itself, or $\phi = k \,.\, \log W_P$.

If the Probability of Perfect Order be nil, the Entropy is Minus Infinity.

105. The Second and Third Laws of Thermodynamics as the dogma of lowest possible temperature and entropy being zero, instead of minus infinity.

SATYENDRA RAY, Lucknow.

The supposed equivalence of every stuff with the Ideal Gas makes the *name* of the lowest temperature Zero, by identifying it with the absolute zero on the Gas Scale; whereas on the gas scale itself it should be minus infinity. (*See last para but one in Abstract No.* 100.)

Similarly the entropy corresponding to the absolute zero is also minus infinity. The definition of entropy for an Ideal Gas

$$\phi=\log v^{s_p} . p^{s_v}$$

gives for v equal to zero, or p equal to zero, the value minus infinity for the absolute zero. Boltzmann's Definition also gives minus infinity for the entropy at absolute zero.

Saha and Srivastava in their Text Book of Heat on page 620 give the equation

$$S_1+S_2=f(W_1)+f(W_2)=f(W_1W_2) \dots\dots\dots\dots\dots \quad (1)$$

and then state, 'This functional equation is satisfied by the relation $S-S_0=k\log(W/W_0)$ where S_0=entropy of some standard state, and W_0=probability corresponding to this standard state'. Now of the Equation (1), $S=k.\log W$ is obviously itself a solution. The form $S-S_0=k.\log(W/W_0)$ is introduced only to provide for Nernst way of *numbering* isentropies in the theory of Boltzmann. To quote Saha and Srivastava:—

Boltzmann's theorem *can* be put in the form $S-S_0=k\log\frac{W}{W_0}$, ...where W=maximum probability of the state under view, W_0= probability of the state in which the order is perfect, when the entropy *can be regarded* as zero. (P. 613.) (Italics are mine.)

We thus see that when both the lowest temperature and entropy possible are minus infinity, we merely *call* these by the name zero, and then prove, or try to prove, that they are inaccessible when this *Inaccessibility* would be stamped on their face, if we called them by the numbers that elementary mathematics teaches them to be.

106. Entropy as identifiable with Avogadro's Number.

SATYENDRA RAY, Lucknow.

That the entropy is variable with Avogadro's Number is indicated dimensionally.

$$[dQ/T]=[Q/T]=\left[\frac{\frac{1}{2}nmc^2}{\frac{3}{2}mc^2}\right]=\left[\frac{n}{k}\right].$$

When the definition dQ/T is wrong for solids obeying Grueneisen's law (*Proceedings I.S.C.*, 1932, Abstract No. 89); and 'disorderliness' cannot be identified with entropy, as shown by the solid-gas model by the author, this indication of dimensions may perhaps be followed up with profit. It is capable of yielding very simple explanation of many phenomena.

107. On Experiments in Acoustic Correction of the U.P. Legislative Council Chamber, Lucknow. (Report by order of C. F. Hunter, Esq., I.S.E. of U.P. P.W.D. for Office File.)

SATYENDRA RAY, Lucknow.

1. It is submitted that the design of the Architect, H. V. Lanchester, has no serious defect except that the radius of curvature is such that

for a speaker near the centre of the floor, the sound is focussed at the same level as the speaker's ear. (The structure is a cylindrical well of radius 40 ft. and height 40 ft. nearly with a spherical dome of radius 60 ft. whose centre is 6 ft. below the centre of the floor.)

2. The author had a scaffolding erected 24 ft. above the floor and spoke from the focus of the dome. Despite the fact that up the ceiling and then down to the floor the path difference was 60 ft., no echo effects were found and the audition all over the floor and the front half of the galleries became very good.

3. Improvement of acoustics could therefore be expected if the 'wasted breath' of the legislators on the floor could be transported from the rostrum or rostrums to this focus and distributed to the galleries which are ill fed with sound energy as it is. Attempting this transport of energy, it was found that the auditio on the floor improved very perceptibly. The galleries did not improve, as Mr. B. K. Bose, B.E., pointed out that the two inch lead pipes with joints and bends were absorbing the sound in its passage through itself. Nevertheless fullest indication of success was furnished to us of the method succeeding if we pushed forward the method.

4. Efficiency of Absorption Material being different at different places, as proved in papers before the U.P. Academy of Science and the Benares Mathematical Society, was then undertaken for investigation. The purdahs put up in the gallery openings (installed in a wrong place as their co-efficient is less than $\frac{1}{5}$), were taken down. A. C. Mukerji, Esq., I.S.E., Executive Engineer, could not find any deterioration with the change.

The 7 purdahs then were suspended from the scaffolding. Speaking now from under the scaffolding, the voice was absolutely muffled.

5. An analogue will make the principle of the correction clear. A bulb in this hall at the centre of it may replace the speaker. A piece of black paper on the wall one square foot in area can be seen to decrease the intensity of illumination on the wall by one in a million. The same area wrapped on the bulb itself will make the hall a photographic dark room. The papers in the U.P. Academy and the Benares Mathematical Society refer to the change in the absorption power with position on the boundary walls and do not by any means give an upper limit to the effective power of absorption of an area which can be increased infinitely if permitted to be placed in the volume of the auditorium.

6. This was the basis of the remark made by the author in a note of date 13th August, 1930, handed to Col. W. de Haga Haig,—'The drapery, combined with an awning to the speakers on the floor (even with seats arranged as now), may be so arranged as to give a maximum acoustic correction with a minimum of area of drapery and awning. And it may be made as artistic as possible at the same time'.

7. The minimum area was next sought. Two durries one above the other folded 66 ft. square, at the heights of 12 and 15 ft. respectively were found sufficient.

8 and 9. The dome makes the acoustics of the marginal zone perfect as it is. The awning would make the central zone perfect. A spherical reflector above the awning, used as a chandelier, would make the middle zone absolutely satisfactory as well.

10. Fresnel's Zones for Central Rostrum. Diffraction helps the acoustic correction. Ten feet is the wavelength of sound for speaking. For the central rostrum, therefore, no sound will go to the dome, and the energy thus saved from being wasted feeds the galleries and the floor.

11. For these experiments the author is under obligation to Messrs. C. F. Hunter, A. C. Mukerji and Ishaq Ali Mirza of the Indian Service of Engineer of U.P., P.W.D.

108. The Robot electric tea maker.

B. D. VIRMANI, Bombay.

This paper describes British Patent No. 396982 and other provisional patents covering improvements over the above patent, all of which relate to a novel type of a machine designed to provide any suitable hot drink, at any predetermined time, giving audible indication that the drink is ready, and during darkness will also automatically light up a lamp at the same time. A special type of a 3-position switch, which, besides controlling the operation of the machine, provides for an independent use of the lamp (a useful point where only one source of supply is available in the room for lighting purposes). The centre of operation is a clock fitted with a contact. Ten minutes before the time to which the indicator is set, this clock contact closes the heater circuit and boils the water, after which other cycles of operations for preparing a complete cup of tea are automatically gone through. When the drink is actually made, the appliance automatically cuts off the heater supply, wakes the sleeper and switches on the light.

The machine is absolutely fool-proof and one of the models will be demonstrated.

109. The effect of temperature in ferromagnetic crystals.

G. S. MAHAJANI, Poona.

The writer begins by making reference to his earlier paper on 'A contribution to the Theory of Ferromagnetic Crystals' published in the *Trans. Roy. Soc., London,* Vol. 228, in which temperature-effects were not considered.

The method suggested in this paper to introduce temperature is somewhat similar to that used by Born in his *Dinamik der Kristallgitter* to attack the problem of the 'specific heats of solids'. The magnetic axes of atoms are assumed to *librate* about the mean position (which is the observed direction of magnetization); and the libration-frequencies are correlated to the temperature by means of the Quantum formula. On the assumption of a 'monochromatic' state the following 'equation of magnetic state' is obtained :—

$$X=\frac{L\sqrt{Y}}{\log(1+M/\sqrt{Y})}$$

where $X=T$ (temperature).

$Y=H$ external $+H$ internal $=H$ (total magnetic field) and L, M are constants.

It is claimed that while Weiss's theory accounted very well for the curves of constant magnetization that he obtained in 1917, the present formula qualitatively explains his later experimental curves in 1926 (and for which his theory fails). His theory gives

$$\frac{\partial^2 H}{\partial T^2}=0$$

and fits in with straight lines obtained in 1917. The present result explains all the three characteristics of the curves in 1926, viz. :—

(1) They are convex to the temperature axis.

(2) As the curves represented by the formula pass all through (0, 0), the effect of taking $Y=H$ external instead of H total is to shift them downwards, and hence they will all cut the Y-axis *below* the origin.

(3) At great distances, the curves tend to become straight lines.

$$X = \frac{L}{M} Y.$$

Quantitative agreement is not satisfactory. It is suggested that a 'polychromatic' formula should be worked out.

110. The Hamiltonian and the form $\sum_{r=1}^{n} p_r dq^r - Hdt$.

K. NAGABHUSANAM, Waltair.

The variational principle of action is taken as

$$\delta \int x_i \, dx^i = 0,$$

where $x_i dx^i$ is a Pfaffian of rank $2n+1$ in the $2n+1$ variables of the manifold of States and Time (the repeated index standing for summation) from 1 to $2n+1$). The Hamiltonian is defined as a function

$$H(x^1 x^2 \; . \; . \; . \; . \; x^{2n+1})$$

such that $x_i dx^i + Hdt$ is of rank $2n$, denoting by t a function

$$t(x^1 x^2 \; . \; . \; . \; x^{2n+1})$$

which is such that both the substitutions t=constant, and its consequence $dt=0$, are necessary to depress the rank of $x_i dx^i$ by one and only one unit. This reduces $x_i dx^i$ to

$$\sum_{r=1}^{n} p_r dq^r - Hdt.$$

The conditions which H satisfies, some properties of H, and the equations of motion in the $(2n+1)$ manifold are given.

111. The equation of state for saturated vapour of ammonia and hydrochloric acid.

J. P. AGARWAL *and* MOHD. KHALIL KHAN GHORY.

From Ray's formula for the Variability of the Avogadro's Number with volume, pressure, and temperature, the equation of state,

$$pv/DT = A \, e^{-a/pvT},$$

derived by him is verified for saturated vapour condition of NH_3 and HCl from data recorded in Landolt and Bornstein's Tables.

112. On the specific heat of electrons in Ferromagnetics.

V. I. VAIDHIANATHAN *and* L. GURDAS RAM, Lahore.

From the change in Thompson Coefficient in Ferromagnetics, it is possible to obtain a quantitative value of the number of effective electron spins per atom in Ferromagnetics. The P, (thermoelectric power) T, values for iron and nickel against platinum were therefore investigated. The P,T, values for nickel against platinum had previously been investigated by Dorfman and Jaanus obtaining 2·91 and 2·85 calories per gram atom for the specific heat of electrons. This was in close agreement with the theoretical value 3. The experiment conducted by the authors do not confirm these values. With the same procedure and accuracy of temperature as was obtained by Dorfman and Jaanus, it has not been possible to obtain consistent values. The experiment really gives the E, T, curve and the specific heat is calculated from the second differential of this curve and the possibility of fluctuation of the value is very high. Further at $T=\theta$ (the Curie point), P_E does not appear to vanish as is required by the theory. More accurate investigation is being undertaken. These were carried out by the authors in connection with the development of an apparatus to utilize the thermo E.M.F. variations to measure the velocity of flow of water at different points in model flumes.

113. The radio synchronograph.

B. B. Deshpande, Belgaum.

114. Raman Effect of some complex cyanides. Contributions to the theory of co-ordinate linkage IV.

R. Samuel *and* Mohd. Jan Khan, Aligarh.

The Raman Effect of complex cyanides of *Cr*, *Co*, *Ni*, *Ru*, and *Rh* is measured. The complexes with co-ordination number 6 showed two Raman lines, one in the region of 2140 cm^{-1} whch belongs to the vibrations of *C* against *N* and a second between 300–600 cm^{-1} belonging to the vibrations of *CN* group against the central metal ion. This last one is missing in complex cyanides with co-ordination number 4 and 3. The higher frequency is a doublet in the case of *Ru* salt. The figures are as follows :—

Salt.	Raman lines (cm^{-1}).
$K_3[Co(CN)_6]$	405, 2148.
$K_4[Cr(CN)_6]$	619, 2130
$K_3[Rh(CN)_6]$	593, 2149.
$K_2[Ni(CN)_4]$	.. 2144.
$K_2[Ni(CN)_3]$	.. 2142.
$K_4[Ru(CN)_6]$	381, 2068, 2107.

This result may be considered as an argument for the covalent nature of the co-ordinate linkage and for a difference in the mechanism of linkage in salts of different co-ordinate linkages.

115. On a Pellian equation.

N. M. Basu *and* T. Vijayaraghavan, Dacca.

In this paper it has been shown that the Pellian equation

$$Dx^2-y^2=1$$

has an infinite number of solutions whenever D is of the form $p^a q^b$, where a and b are any two integers and p and q are any two primes of the form $4n+1$ and such that the Legendre symbol $\left(\frac{p}{q}\right)=-1$.

116. A '*k*-analogue'.

S. Chowla, Waltair.

Let $\chi(n)$ denote a real primitive character (mod k). The author proves that

$$\text{(A)} \qquad \sum_{1}^{\infty} \frac{\chi(n)}{n}=\Omega_R\ (\log\log k)$$

which is the k-analogue of Bohr-Landau's

$$|\zeta(1+ti)|=\Omega\ (\log\log t).$$

(A) was proved by Littlewood (1928) on the basis of infinitely many unproved assumptions.

117. Primes in arithmetical progression.

S. Chowla, Waltair.

Let $(k, l)=1$, $\pi(x;\ k, l)$ denote the number of primes $\equiv l \pmod k$ not exceeding x, $\phi(n)$ Euler's totient function.

Theorem 1A. *If* $x \geqslant exp(k^c)$, *where* $c>\frac{1}{2}$, *then*

$$\lim_{k\to\infty} \frac{\pi(x;\ k, l)}{x/\phi(k)\log x}=1.$$

Theorem 1B. *If Theorem* 1A *is true for any* $c<\frac{1}{2}$ *then some of Gauss' (hitherto unproved) class-number conjectures would follow.*

A consequence of Theorem 1A is a proof of a Hardy-Littlewood conjecture on the number of representations of an integer as a sum of four squares and a prime.

118. On sums of fifth powers.

S. Chowla *and* S. Sastry, Waltair.

In a famous passage generalizing Fermat's Last Theorem Euler seems to conjecture that

$$(1) \qquad x_1^k+\ldots+x_k^k=y^k$$

is possible in integers if $k\geqslant 4$, in confirmation of which we have

$353^4=30^4+120^4+272^4+315^4$ (Norrie 1911).

$107^5=7^5+43^5+57^5+80^5+100^5$ (Sastry 1933).

Generalizing Sastry it is shown that (1) has infinitely many non-trivial solutions in positive integers.

119. Pull of solenoids.

P. Govindakrishnayya, Waltair.

Following the work of Underhill, an improved form of apparatus is devised to study the pull of electromagnets. The paper describes the results obtained under the following conditions using a commercial type of solenoid, which is alternatively excited by direct and alternating currents :—

(*a*) Plain Solenoid.
(*b*) Iron clad Solenoid.
(*c*) Iron clad Solenoid with stops of different lengths.

Curves are plotted to show the relation between the pull on the plunger and the air gap. Amongst the many interesting features exhibited by the curves, the fact that there is a sharp hump as we reach the middle of the coil may be noted here. This is attributed to the special characteristics of the coil used. A detailed explanation of the curves is now being attempted.

120. The determination of the values of Γ for air saturated with water vapour at various temperatures.

Haji Gulam Muhammad, Allahabad.

The value of Γ is very important from the thermodynamical point of view; and a precise study of its variation has an important bearing on the molecular structure of gases and is of great help towards a better understanding of their dissociation equilibria. In the present paper the author has reported some precise results of his experiments on the determination of Γ for air saturated with water vapour at various temperatures, ranging between about 15°C. and 80°C.

The method used was to determine accurately the velocity of sound in saturated air at various temperatures, by setting up stationary waves in the resonating tube of a large diameter (6·08 cms.), by means of a telephone actuated by a source of constant frequency (994 cycles per second), viz.: a valve-maintained tuning-fork oscillator and directly measuring the internodal distances $\frac{\lambda}{2}$, the half wavelength. The tube-velocity of sound was then calculated by using the fundamental formula,

$$V = N \, . \, \lambda \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (1)$$

The main portion of the apparatus is shown in fig. (i). The frequency of the note (to set up the stationary waves in the resonating tube) under the actual experimental conditions was accurately determined by comparison with another certified tuning-fork made of elinvar steel (Valentine and Carr) of frequency 1,000 cycles per second. The temperature of the saturated air in the resonating tube was controlled and measured with an accuracy of about 0·1°C, and the accuracy of locating the points of maximum sound-intensity was within 0·2 mm. The distances between the successive maxima were measured by the comparator method by making use of a travelling microscope. The tube-corrections at various temperatures were determined experimentally by assuming the Helmholtz-Kirchhoff equation (2), given below, to be valid for all practical purposes, in the case of resonating tubes having smooth surface,

$$V = V_0 \left\{ 1 - \frac{C}{2R\sqrt{\pi \, . \, N}} \right\} \quad \ldots \quad \ldots \quad \ldots \quad (2)$$

where

V is the apparent velocity of sound in gases in tube,

V_0 is the free space velocity,

C is the Kirchhoff constant,

R is the radius of the tubes and N is the frequency of the source of sound.

The free space values of the velocity of sound in the saturated air were determined at various temperatures.

The values of Γ were calculated by the formula,

$$V_0 = \sqrt{\Gamma \, . \, P / \rho} \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (3)$$

V_0 was obtained accurately from the velocity-temperature curve, drawn on a very large squared paper. P was read on a Fortins barometer, and ρ the density of the saturated air at various temperatures was obtained by calculating the density of dry air at any particular temperature and the partial pressure of dry air in saturated air at that temperature and adding to this the density of the moisture (ρ_m) at that particular temperature. The values of ρ_m at various temperatures were calculated from Landolt's Table of Contents, but more weight was given to the experimental values of the same (ρ_m) obtained from a paper by J. H. Awbery (*Proc. Phys. Soc.*, 143, 1932).

Curves were drawn showing the variation of Γ with temperature, as well as with the moisture content in the saturated air.

Having done this, we have calculated the values of γ_m, the ratio of the two specific heats for the moisture, contained in saturated air at various temperatures by using Einstein's theoretical expression

$$\frac{P}{\Gamma-1}=\frac{p_d}{\gamma_d-1}+\frac{p_m}{\gamma_m-1} \qquad \cdots \quad \cdots \quad \cdots \quad (4)$$

The most probable values of γ_d for pure dry air were taken from the works of other experimenters.

Curves have been drawn depicting the variation of γ_m with termperature, with moisture content and with vapour pressure of water.

On the strength of the utmost care taken to avoid practically all the sources of error inherent in the tube experiments, we hope that our results are correct to about 2 parts in 1000.

Section of Chemistry.

President :—Prof. H. B. Dunnicliff, M.A., Sc.D., F.I.C., I.E.S.

Presidential Address.

The Rôle of Chemistry in the Advancement of India.

For some years past it has been the custom for Presidents of the Chemistry Section of the Indian Science Congress to give a review of recent advances in some specialized branch of our subject. The honour of addressing you as President has come to me at a time when all things in India are about to undergo transition and readjustment and it is a matter of great importance and urgency that all chemists should realize their responsibility to the community and appreciate how, in the spirit of service, they can subscribe to the progress of their native land and bring to their fellow men the benefits of systematic scientific study.

Chemistry and Culture.

I propose, therefore, to attempt a short review of the part which chemistry may play in India's future, not only in the field of disciplined scientific achievement but also in the sphere of intellectual culture. One must remember that utility is not the only appeal of chemistry. The ideal of all who teach or work in this field should be to imbue those who come under their influence with the fundamental spirit of science, the first aim of which is the revelation of truth. It is this spirit of inquisitiveness which should draw even elementary students to the laboratory. To foster and develop the desire to seek out the true explanation or observation of simple phenomena is of prime educative value because it encourages thought in the correct manner and in the right direction. From this it must not be inferred that science only observes, collects, and interprets facts. The best of minds do not stop here. They have imagination which leads them to predict new phenomena, and attempt to reveal the unknown. Scientific truth through which man derives intellectual satisfaction is based on a passion for facts and verifiable knowledge and on the orderly arrangement and grouping together of related facts into scientific laws. This scientific truth is truth regarding the whole material universe and man's activities, in so far as these can be studied by the method of Science. Scientific truth, therefore, is one of the humanities, one of the great human values, necessary for a complete life. For that reason its cultivation must be urged with insistence.' (A. Findlay, 1933.) Hence it is of immediate importance that chemistry should be taught adequately in our universities.

A university is an association of men and women for the purpose of study and for extending the boundaries of knowledge. It is the duty of a university so to arrange its courses of teaching and administration that its alumni may receive theoretical and practical guidance in studying and resolving the problems which have arisen and are arising in the development of civilization.

I would particularly stress the last four words because I feel that always, but now more than ever, it is most important that men should be trained in a sense of civic responsibility and the practical applications of modern science. If our universities could claim to make thousands of good citizens as well as a few super-experts in specialized fields, I feel their basic and essential function would be served. After all, it is not because the teaching is better at Oxford and Cambridge than it is at London, Liverpool or the other new Universities that men and women seek admission to these ancient seats of learning in increasing numbers. Such a suggestion would demand most critical investigation. It is the life as a resident member of an intellectual and healthy community which counts so much. What India needs at present is a development of real civic and national sense the key-note of which is the subordination of self to the common cause. The beginnings of these are developed by intimate personal contacts in work and play.

In India there is an ever increasing demand for men of culture in the nation's service—men who, by striving to acquaint themselves with the results of intellectual activities in those departments of knowledge which conduce to general or individual welfare, correct living and rational conduct, are qualified to take their places as useful members of corporate society and to assume their share in their country's development.

By 'culture', I understand a systematic improvement of the mind leading to refinement and enlightenment—that which makes its aim the improvement of the whole man, bodily, mentally, and as a member of organized society. Some have suggested that such subjects as chemical technology are strictly speaking outside the scope of university teaching and that instruction in these subjects should be given in special institutes. I differ from this view and hold that, since the study of modern sciences has as its sole object the improvement of the conditions and amenities of life, they are cultural and I am emphatically in favour of professional subjects being taught within the scope of the university. To me there is no difference in principle between Law and Medicine, which all admit are suitable subjects for a University and Agriculture, Technical Chemistry or

Engineering, the place of which in university curricula some would dispute. All are 'cultural' within the scope of my definition in that they assist in the development of civilization and inspire mutual help among our fellow-men.

THE TEACHING PROFESSION.

It is almost essential for a man who intends to adopt chemistry as his career to possess a university degree. It is obviously of great advantage to him if he has learnt to appreciate the value of the science through careful teaching.

It is necessary to put junior students into the hands of capable teachers who appreciate the value of an adequate course of laboratory work in which regularity of attendance, cleanliness of operation, and honest and accurate reporting are insisted upon. This early discipline will be of permanent value to the man, whether he continues to pursue a scientific career or not.

For those who intend to enter the teaching profession, the acquisition of a degree should be followed by one or two years' training in the methods of research. During this period they should not be merely the assistants of a professor doing his bidding under his constant supervision but they should be stimulated by contact with an enthusiastic teacher to develop individual methods of experimentation, to increase their power of observation, and to learn how to reason out the conclusions which can be drawn from the recorded phenomena and data. I think my colleagues will agree with me when I say that, in assessing the value of students' M.Sc. theses, often without a *viva voce* examination, the examiner frequently has the greatest difficulty in evaluating the work as he feels that the brain behind it is practically entirely the teacher's, though the experimental work has actually been done by the student.

In my opinion, many Boards of Studies and Boards of Control are not brave enough in maintaining the standard of teaching by insisting on a steadily improving degree of attainment in the public examinations. Students crowd into the classes too young and with insufficient knowledge of English and fundamental words to understand the lectures properly. If the examination results as submitted by the examiner show a low percentage of passes, the examiners or the paper-setters are often criticized in the press and the complaints get sympathetic hearing by the University authorities. The attack is directed at the wrong point. My view is that, while admitting the fact that students enter classes too young owing to the removal of a low age limit for Matriculation, and conceding the consequent evil of forcing of children to learn and cram too quickly, we suffer more from a large proportion of teachers lacking enthusiasm than from pupils lacking brains. Critics tend to say the students are overburdened with work rather than to advocate concentration on improved methods of teaching. In other words education, at any rate in its humbler spheres, is failing to attract the best men in sufficient numbers. This is, in part at least, due to the poor salaries paid to teachers. It is rather sad that the development of youth is in the hands largely of men who enter the under-paid ranks of the teaching profession because other avenues of employment are not available and it is not out of place to invite the attention of our legislators to the necessity for giving prospects to teachers which are comparable with the aspirations of other respected professions. In higher spheres my experience is that, in many places, the teaching is of the most superficial kind and it does not strike one that certain universities are desirous of an improvement in standard and repute when, although they ask the examiner for a suitable standard of test and invite his criticism on the courses of study, a very low percentage of passes or an adverse report may be countered by removing the examiner from the board. These are not principles on which the advancement of a 'key' subject depends. The teaching of chemistry is not easy and it certainly is not cheap and, in my opinion, it is better to remove the subject from the schedules of institutions which cannot afford it than to teach it badly. May I make the appeal that if these comments appear severe, they may be taken in the spirit in which they are offered, that they may not give offence but that they may stimulate thought. My audience is mainly of senior men who can make their influence felt, particularly in the teaching profession and I appeal to you to encourage your students not only to learn chemical facts and practice but to 'think chemically'.

Responsibility is ours. Let us shoulder it, not only willingly, but enthusiastically.

TECHNICAL EDUCATION.

While it is true that every country cannot foster every industry it is evident India can and should develop industrially more of her agricultural and mineral resources. In all these industries, chemistry in one or more of its branches will be of integral importance but it must be remembered that manufacturers must be able to compete with the imported articles in both quality and price or Government subsidies or protection will be the only possible way of keeping the industries going. At present it is perhaps true that some success is achieved with the aid of a certain number of factory chemists, who are acquainted with the operations they carry out and the manufacture of commercial products on a large scale but, if the resources of the country are to be properly exploited, it will be absolutely necessary for India to have at her disposal a large number of chemical technologists who both understand what process they are controlling and the mechanical method by which results may be obtained, and are also capable of discussing outturn from the economic and theoretical standpoint with a view to manufacturing their products speedily, cheaply, and of good quality. Industrial success is impossible unless high standards of quality are maintained at economical rates by scientific control. The need for cheap trade production was never more urgent than at the present time but it must be understood that cheap production is not emphasized in the interests of share-holders in companies but because it is a matter of self-preservation for the masses. Hence, there is no question that, if India is going to take her proper place among the nations of the world, she must develop the wealth of the country, not merely by fostering agricultural expansion which is bound to occur as a consequence of the completion of such projects as the Sukkur Barrage which will render fertile lakhs of undeveloped acres, but by following this up with the industrial development of her increasing agricultural wealth and its bye-products into useful and saleable articles. The difference between a pure and an industrial chemist is only relative and, whether a man intends to follow an academic or commercial career, it is imperative that he should undergo a recognized course of training in inorganic, organic, and physical chemistry, illustrated by a thorough laboratory programme in these three branches of the science. As a result of a recent conference in Lahore, we have decided to incorporate into our Honours School of Chemistry a short course of chemical technology and machine drawing for all candidates aspiring to honours. This has been approved, not with the idea of converting every chemistry student into a technologist, but because we feel that no man who intends to study chemistry seriously or make it his profession can have a reasonably sound grounding in the subject unless his early attention is drawn to the industrial point of view on a limited scale but in a proper manner. Our revised scheme provides that the courses preparing men for either academic or commercial careers which up to now have differed, shall be identical for three years, and that, after that period of thorough grounding, bifurcation should start—the pure chemist proceeding to academic research, the prospective technologist specialising in the principles of engineering, mechanical drawing, the study of a selected industry and general technical analytical methods. Industrial research, in my opinion, can only be done profitably after experience at the works and the practical appreciation of what large scale production really means. Our business men have been very generous in permitting students go to their factories to study, but it is only in the nature of things that such instruction has been of rather a general description and that the technical and administrative staff are naturally somewhat reluctant to impart information on actual details about patent methods, special plant, efficiency of yield or other information upon which the success of that factory or the individuality of its products depends. Chemists trained in the manner described above, even without special courses in engineering and other subjects set forth in the post-graduate scheme, are usually acceptable to manufacturers in England and America and recently there is evidence that industrialists in India are quite content to employ honours graduates who do not claim to have any previous factory experience. The graduate will eventually acquire this through actual practice in the works where, as a member of the staff, he learns infinitely more than he could ever have been told or appreciated as a student passing through. The need for chemical engineers and chemical technologists will undoubtedly increase as the country develops. I am of the opinion that every university which teaches chemistry to the Honours School or Master's Degree stage should have, as part of its standard equipment, a laboratory in which small scale models of the commoner plant employed in chemical manufacture are available for actual operation. These should not merely be demonstrated to the students but should be used by them as a part of the standard practical curriculum. If universities make a steady effort to provide men with a thoroughly efficient grounding in chemistry I do not think that employers in chemical works will fail to find that they are assets to their staff, that is, if the chemists themselves are hardworking.

I do not wish to create the impression that technical chemical appointments are only available for the fully qualified university graduate. Men may join the ranks of chemical industry either at the undergraduate, the graduate or the post-graduate stage. In the limited time at my disposal I have chosen to deal with the post-honours school point of entry as the most likely to appeal to my present audience and as, probably, the most suitable point of entry for the Indian candidate.

Assuming, then, that a man has had a suitable grounding in chemistry and other allied subjects, let us see what careers are available for him.

I have prepared lists of possible careers (Table I) and actual appointments in India (Tables II and III) from which it will be seen that the student who chooses chemistry as his profession has many openings before him. These lists are not complete but they give some idea of the very wide range of interests over which the chemist exerts his influence.

A glance at the list will show that the Government of India and Local Governments have realized the importance of the chemical profession in its technical departments. There is, however, much scope for desirable expansion as, in India at the present time, chemists have frequently to serve in several capacities each of which would be dealt with by a separate man in countries where the profession is better organized.

I propose now to refer to several aspects of the subject which are of importance to those who wish to earn their livelihood by the pursuit of chemistry.

CHEMISTS IN COMMERCE.

The number of qualified chemists working in a consultant capacity or as works managers or chemists in factories in India is comparatively small. I attempted to make a list of these but my information was so incomplete that it would have given a false and pessimistic impression. Perhaps it is sufficient to say that I had found some sixty appointments but, although there must be many more than this, the total number is still quite inadequate to meet the requirements of so vast a country as India.

As I have just said, the nature and scope of the chemical appointments under the Government of India and Local Governments show that the official mind is aware of the economic importance of chemistry. Private employers are also engaging chemists in increasing numbers. The wide range of the interests involved is an indication of the recognition of its significance in all official and commercial spheres but particularly in agricultural and in analytical work. While appreciating past achievement, much remains to be done and I still hope for the day when public health will not be a 'provincial' subject but, if I may so describe it, a 'municipal' subject in which every local body provides for, at any rate, urban sanitation and the examination and certification of pure foods for all consumers.

TABLE I.

AVENUES OF EMPLOYMENT FOR CHEMISTS.

EDUCATION including.

University: Professors, Readers, Lecturers, and Demonstrators.

Professional Colleges and Technical School and Institutes.

Schools: Science Masters.

IN INDUSTRY, i.e. Factory work.

In the Laboratory: Analytical and chemical control work.

In the Works. Manufacture: Suggestions regarding control of labour, improvement of plant, and careful supervision of costs.

Research: On the works, leading to greater efficiency of existing plant and designing of plant to increase rate, quality, and economy of outturn. Utilization of waste and bye-products.

Works Manager: probably having several different departments under this control.

CONSULTANT TECHNOLOGIST OR CHEMICAL ENGINEER.

PUBLIC HEALTH: Foods, drugs, medicines, biochemical work, sewage disposal, and water supply; medico-legal analytical work.

PHARMACOLOGY: Druggists and Dispensing Chemists.

PUBLIC ANALYSTS to Local Governments, Municipalities, etc. Private practice.

METALLURGICAL WORKS:

OFFICIAL APPOINTMENTS UNDER THE GOVERNMENT OF INDIA—*Vide* Table II.

OTHER OFFICIAL APPOINTMENTS UNDER LOCAL GOVERNMENTS (*Non-Educational*)—*Vide* Table III.

MISCELLANEOUS:

Professions such as law, journalism, and commerce in certain departments of which a special knowledge of chemistry would be valuable and is far too often totally absent.

TABLE II.

GOVERNMENT OF INDIA APPOINTMENTS.

Imperial Institute of Agricultural Research (Pusa).

Imperial Agricultural Chemist.
Physiological Chemist.
First Assistant to that Imperial Agricultural Chemist.
First Assistant, Bacteriological Section.

Imperial Institute of Animal Husbandry and Dairying (Bangalore and Wellington); Imperial Cattle Breeding Farm (Karnal); Imperial Dairy Factory (Anand).

Physiological Chemist (Animal Nutrition).
First Assistant to Physiological Chemist (Bangalore).

Technological Research Laboratory (Matunga, Bombay).

Indian Central Cotton Committee.

Senior Research Chemist.
Assistant Technologist.
Two Physicists and a Microscopist.

Institute of Plant Industry (Indore).

Chief Chemical Assistant.

Indian Lac Research Institute.

Director (Chemist).

Indian Tea Association (Assam).

Chief Scientific Officer.
Chemists 4

Imperial Council of Agricultural Research.

Animal Nutrition Problems: One Chemist and two Assistants.

Colloid Soil Constituents: Two Chemists (Calcutta).

Effect of Ions on Plant Growth: One Research Chemist (Lahore).

Standardization of Physico-chemical Single Value Measurements: One Research Chemist (Lahore).

Imperial Institute of Veterinary Research (Muktesar).

Bio-Chemist.

Forest Department (Dehra Dun).

Bio-Chemist and two Chemical Assistants.

Archæological Department (Dehra Dun).

Archæological Chemist.

Indian Medical Service (Medical Stores).

Two Chemists (Madras and Bombay).

Government Central Distillery (Nasik).

Chemist.

Army Department.

Officers in Ordinance Factories and Arsenals who possess chemical qualifications:—

Superintendent, Cordite Factory, Aruvankadu.
Works Manager, Cordite Factory.
Assistant Works Managers, Cordite Factory .. 4
Assistant Works Manager, Metal and Steel Factory, Ishapore.
Assistant Works Manager, Harness and Saddlery Factory, Cawnpore.
Assistant Chief Inspector of Stores and Clothing, Cawnpore.

Indian State Railways.

Chemists and Metallurgists 4
Assistant Chemist and Metallurgist.

Indian Stores Department.

Metallurgical Inspector.
Assistant Metallurgical Inspector.
Superintendent, Government Test House, Alipore.
Chemist, Government Test House, Alipore.
Assistant Chemist, Government Test House, Alipore.
Chemical Assistants 18

Indian School of Mines.

Professor of Chemistry and Assaying.

Mint and Assay Department.

Assay Master, Mint, Bombay.
Deputy Assay Master.
Superintendent
Assistant Superintendents 2

Finance Department, Central Revenues.

Control Laboratory.

Chemical Adviser.
Personal Assistant (Chemist).
Chemical Assistant.

Customs Department.

Chemical Examiners 2
Assistant Chemical Examiners .. 4
Chemical Assistants 16

Opium Department.

Opium Chemist.

Ordnance Department.

Controller of Chemical Defence Research.
Assistant Controller of Chemical Defence Research.
Chemical Inspector, Indian Ordnance Department.
Assistant Chemical Inspector, Indian Ordnance Department.
Chemists, Inspectorate of Chemical Stores .. 4

Explosives Department.

Chief Inspector of Explosives.
Inspectors of Explosives 2

TABLE III.

APPOINTMENTS UNDER LOCAL GOVERNMENT OR IN INDIAN STATES.

(Not including Educational Appointments.)

Assam.

Agricultural Chemist.

Bengal.

Agricultural Chemist.
Assistant Agricultural Chemist.
Fibre Expert (Dacca).
Assistant Fibre Expert.
Research Chemist, Bengal Tanning Institute.
Assistant Director, Bose Research Institute (Chemist).

Quinologist, Government of Bengal.
Assistant Quinologist.
Analyst, Calcutta Municipality.
Assistant Analysts 4
Pulta Waterworks, Assistant Analyst.
Hogg Milk Market Laboratory, Assistant Analyst.

Bihar and Orissa.

Agricultural Chemist and two Assistants.

Burma.

Chemical Examiner.
Agricultural Chemist.
Municipal Analyst.
Bacteriological Chemist.
Official Agricultural Analyst.
Chemist, Institute of Public Health, Rangoon.
Assistant Chemist. Institute of Public Health, Rangoon.

Bombay.

Agricultural Chemist.
Soil Physicist and Agricultural Chemist.
Cotton Physiologist and one Assistant.

Bhopal.

State Chemist and Director of Agriculture.

Central Provinces.

Agricultural Chemist and Two Assistants.

Hyderabad.

Government Industrial Chemist.

Madras.

Public Analyst, Government of Madras.
Agricultural Chemist.
Agricultural Biologist.
Three Assistant Agricultural Chemists.
Chemists, Government Chincona Department.
Government Oil Chemist and Soap Expert.

Mysore.

Agricultural Chemist and 5 Assistant Chemists.
Three Analysts.
Industrial Chemist.
Chemical Examiner.
Industrial Chemist, Soap Factory.

Punjab.

Two Agricultural Chemists.
Assistant to Agricultural Chemist.
Research Assistants.
Public Health Chemist.
Agricultural Bacteriologist.
Director, Irrigation Research Institute.
Physical Chemist, Irrigation Research Institute.
Four Assistant Chemists.
Industrial Chemist to Punjab Government.
Industrial Surveyors (Chemists).

Rajputana.

Analytical Chemist (Water).

Travancore.

Government Industrial Chemist.

United Provinces.

Chemical Examiner.
Assistant Chemical Examiner.
Industrial Chemist to the Government of U.P.
Director of Agriculture.
Public Analyst.
Deputy Analyst, U.P. Government.

Reference to Tables II and III will show that there is a sad lack of appointments which control drugs and medicines. As things stand at present, pharmacy is merely a commercial proposition which involves neither education nor training. The adulteration of drugs incurs no penalties and no regular control is exercised over imported drugs or those manufactured in India.

Most people do not know that 'pharmacy' includes the collection, preservation, preparation and manufacture of medicinal substances whether they be obtained from animal, vegetable or mineral sources. To-day in western countries, the course of study for the diploma of a qualified chemist and druggist resembles in standard and range of subjects that which is required for a University degree. It is time that the public was protected from quacks by organizing the profession of pharmacy on strictly regulated lines.

PHARMACOLOGY AND THE CONTROL OF DRUGS.

In 1927, the Council of State recommended the Governor General in Council to urge all Provincial Governments to take necessary steps to control the indiscriminate use of medicinal drugs and to legislate for the preparation, standardization, and sale of such drugs. In 1930, the Department of Education, Health, and Lands appointed the Drugs Enquiry Committee to explore and define the scope of this problem and to make concrete proposals as to the measures which should be taken. The Committee was asked to state what action they proposed in order that control might be exercised over the preparation and sale of drugs and chemicals recognized by the British Pharmacopœia, known and approved medicinal preparations other than those included in the British Pharmacopœia and made from indigenous drugs and chemicals and, further, to present a scheme for the organization of the profession of pharmacy. The Committee recommended that legislation should be provided to organize the manufacture, import, and sale of drugs which should be distinct from that regulating the quality of foodstuffs, the essential difference being that matters affecting drugs, sera, and medicines should be under a Government of India Department, whereas foods would be under provincial authority. They advocated the organization of the practice of pharmacy into a State-recognized profession and the creation of a Central Control Laboratory, either at Bombay or Calcutta, under a Director assisted by an expert staff and suggested that it should consist of two departments, one for Pharmacology and Biochemistry and the other for Chemistry and Pharmacy. Its functions would be to conduct research work on the pharmacological examination of drugs and sera, to train analysts, to undertake commercial testing on payment, to initiate standardization, control and consultant work, including advice on manufacturing processes, the plant required and the technical difficulties involved, and to issue bulletins on the progress achieved in the various branches of its activities.

They also recommended that steps should be taken to compile an Indian Pharmacopœia on the model of the existing British and U.S. Pharmacopœias which should describe the preparation, dosage, and assay of such therapeutically active substances and pharmaceutical necessities as are found suitable for India. It should also include substitutes and additions from the indigenous *materia medica.* They further emphasized the necessity for every Local Government to establish and maintain a testing and advisory laboratory in the Province under the direction of a public analyst assisted by a suitable staff. The scope of these laboratories would be different from that of the existing Chemical Examiners' laboratories in that they would be accessible to the public on payment of fees and deal only with drugs and medicinal preparations.

The Committee urged Government to restrain unqualified persons from entering the profession of pharmacy and insisted that all persons in chemists' shops should hold a pharmacist's diploma which would be awarded after a suitable course of study in chemistry, botany as applied to pharmacy, physics, and the usual pharmaceutical subjects. They also recommended that no person should be allowed to dispense medicines either in shops or hospitals unless they themselves were certificated pharmacists or under the personal supervision of a qualified man and advocated the compulsory registration of all patent and proprietary medicines having secret formulas. In order to realize these objects they desired that Universities in India should be required to give training in advanced Pharmaceutical Chemistry and to institute a degree in the subject.

The Drugs Enquiry Committee completed its work in 1931 and published its report in 1932 but, so far as I am aware, nothing, excepting an approach to the universities on the subject of classes in pharmacy, has been done to implement any of these recommendations. In the present time of financial difficulties it is scarcely likely that the entire scheme could be put into early execution but a report of such integral importance to the whole of India should not be completely relegated to the archives until funds for the whole scheme become available. I feel that, if the Government of India appealed to all the laboratories in the country in a suitably worded circular giving a schedule of the work to be done, they would find that the majority of them would be prepared and qualified to accept responsibility for some part of this work. Perhaps a few might carry out researches on indigenous drugs, some could give instruction in pharmacy, while others would undertake the work which should be done by public analysts but which now is done by no one. I venture to suggest that, without further delay, the Department of Education, Health, and Lands should appoint an experienced pharmacologist to draw up a programme and circularize the laboratories in India asking them in what portion of such a scheme they could participate either for the Provincial or for the Central Government. So far as expense is concerned, it is probable that the laboratories which came voluntarily into such a scheme would provide the funds required for the investigations allotted to them from their own resources and thus the only cost to the Government of India would be for one first class organizing officer (a pharmaceutical chemist) and one or two assistants working in a suitable existing central laboratory. The immediate duty of the controlling agency would be to prepare a detailed schedule of work for circulation, to co-ordinate the work done, to confirm results obtained, and to commence the compilation of the Indian Pharmacopœia at once.

APPOINTMENTS HELD BY OFFICERS OF THE INDIAN MEDICAL SERVICE.

I have often heard chemists protest that two classes of appointments held by members of the Indian Medical Service, i.e. officers in charge of Medical Stores Depots and Chemical Examiners to Local Governments should be reserved for specialists in chemistry. In reviewing the prospects of our profession in India I feel that some explanatory statement on this question is called for. I have discussed it with several senior officers of the Indian Medical Service who have special knowledge and their case against these appointments being held by civilian chemists is as follows: The Medical Stores Depots are primarily intended as military formations for supplying the requirements of the army, although civil institutions are permitted to use them on application to the proper authority. These depots contain a large staff ranging from 111 at Calcutta to 150 in Bombay and consequently, so far as the head of the depot is concerned, administration is his principal duty. As these depots are military units, the officers in charge are Indian Medical Service men in military employ assisted by assistant surgeons and sub-assistant surgeons, also in military employ, but the remaining staff is civilian and under Civil Service Regulations. The mobilization of such officers would come under the rules of the Army Act. If an attempt were made to put chemists in charge of Military Stores Depots, even with military rank, it would be necessary either to give them a very high rank to start with, which, for administrative purposes, would obviously be impossible, or they would have to enter the department with a rank equal to that of an assistant or sub-assistant surgeon and an anomalous position would be created in which the officer commanding would be considerably junior in every way to a number of the officers subordinate to him. All the officers in charge at present are comparatively senior men and consequently no such difficulty arises. Although the officer in charge should have a knowledge of pharmacology, he need not be an expert general chemist since, as pointed out above, his work is mainly administrative.

In the two manufacturing departments at Bombay and Madras where a great deal of chemical work is done, a civilian chemist is in charge of the factory but he is not concerned with organization. Chemical questions from other non-manufacturing depots are referred to them or to the chemical examiner to the local government but, apart from Madras and Bombay, there are no chemical laboratories in the stores depots and Medical Storekeepers are not required to do testing work. Officers in charge of these depots form a war reserve and are likely to be called out on active service in the event of mobilization. Their places would be filled by others having a knowledge of military routine and administration. If civilian chemists were employed they could not be called up for war service as there would be no one to replace them in the same capacity. On the other hand, it is essential that officers in charge of stores depots should possess medical and surgical knowledge as they are dealing entirely with medical officers who subsequently refer to them, questions dealing with drugs and also with the selection and testing of medical instruments and appliances and other technical matters. It would be most improbable that a civilian chemist would have such specialized knowledge as would enable him to deal with these varied duties. In any case, the number of officers in the Medical Stores Depots, including a leave reserve and one at headquarters, is only six and, in view of the many appointments open to chemists in which chemical knowledge is the first consideration, the question of the further employment of chemists in the medical stores depots seems to be of minor importance. In England, the Army Medical Stores are under the charge of a quarter-master, R.A.M.C. holding the rank of major while, at the War Office, the administrative staff dealing with medical stores are qualified doctors.

Chemical Examiners.

The case of chemical examiners, however, is somewhat different. Many chemists feel that, when one realizes how small the amount of general and analytical chemistry the medical man studies in his professional course, it might be no more difficult for a trained chemist to learn what is required of medicine to become a chemical examiner than it is for the medical man to acquire sufficient knowledge of analytical chemistry to fill the same appointment. My doctor friends protest that this impression is not justified because the chemical examiner, in addition to a knowledge of chemistry, is required to have an intimate acquaintance with many branches of medical work, including microscopy, biology, pathology, and anatomy and, on his laboratory staff there are pure analytical chemists to carry out analytical processes, though in many places the proportion of such analysts is too low. He is frequently required to identify exhibits such as an organ or the part of a bone, or to certify that wounds or injuries are due to a specific cause or to assess the quantity of a drug in the whole body from the amount found in a single organ, and so on. Hence, it is argued that the knowledge of medicine required of a chemical examiner is very comprehensive and the suggestion that a chemist can do the analyzing and the medical man undergo cross examination in court is opposed by the Indian Medical Service. They maintain that, right from the commencement of his hospital training, the medical man studies problems which will come to him in his capacity as a chemical examiner so that, if he decides to take up such an appointment, he can become a very efficient chemist while possessing all the necessary qualifications of a doctor. This may be so, but I still feel that while conceding the case of the medical storekeeper the question of chemical examiners is still open and one is faced by the fact that already there are two chemical examiners under Local Governments who are not medical men and I understand that similar appointments of chemical specialists to more of these posts are being considered.

AN INDIAN CHEMICAL SERVICE.

In 1920, Professor J. F. Thorpe, President of a Committee appointed to enquire into the possibility and desirability of instituting a Government Chemical Service in India, expressed the view that the development of chemical industries in India could only be adequately realized through the agency of an efficient Government Chemical Service having as its primary objective the encouragement of industrial research and development. The chief recommendations of the Committee were (1) that a Service be created under the direction of a Director General and that a Central Imperial Research Institute should be erected at Dehra Dun having four departments (*a*) Inorganic and Physical, (*b*) Organic, (*c*) Metallurgical, and (*d*) Analytical and that the functions of the Central Institute should be (1) to create new industries and carry out the development of new processes on a large scale and to expand them further if necessary, (2) to investigate problems of a fundamental nature referred from Provincial Institutes, (3) to assist in the co-ordination of the work being done in the provinces by personal discussion and touring, (4) to correlate analytical methods in use in India, (5) to maintain a record office and information bureau, and (6) to issue publications.

It was proposed that Provincial Research Institutes under each Local Government should be built near the chief seat of industry in the province and that the functions of the provincial research institute should be (1) to maintain contact with the work of chemists and factories generally and to solve any problems submitted to them, (2) to develop and place on a manufacturing scale new processes previously worked out by the Central Research Institute, (3) to attempt to establish and foster new industries peculiar to the Province, (4) to do chemical and analytical work, (5) to erect and control sub-stations within the Province, as required.

The institute would be available to the public for chemical advice or investigations on payment, and members of the service could be deputed to private firms on a financial basis. It was proposed *inter alia* that the Local Government public analyst should be attached to the provincial research institutes and that the chemical work now carried out by the chemical examiners to Local Governments and the Government Test House, Alipore should be under the control of the Director of Research. Agricultural chemists and chemists working in educational appointments were not included in the cadre.

Nothing has been done to inaugurate this service, firstly because it was very expensive and secondly because there was no unanimity of opinion in the various departments concerned regarding the advisability of transferring such chemical appointments as already existed to another authority.

Manufacturers are agreed that any industry which depends on chemistry for its basis, must improve or develop its scope by research work. In large factories, laboratories form an integral part and discoveries made in them are used in the development of business for owners. This is most desirable but it often happens that there are problems which it would not pay the firm to investigate, while others, particularly the working up of bye-products, are frequently left undeveloped—either because they are not recognized as important or because the industry pays well enough without their utilization.

In England, this is dealt with by State-aided research associations but the Chemical Services Committee felt that Indian conditions were not yet suited for such a system and suggested provincially controlled research laboratories and a central Imperial Research Institute. Their scheme envisaged that problems would be investigated at the provincial or central institutes and, when developed in these institutes, would be opened up in the factory of the manufacturer interested, who would pay the expenses of a Chemical Service man, deputed to him by the Department of Chemical Research, until the plant was erected and the process developed.

I do not think there would be much support for such a scheme now. The tendency would be for the firm to engage their chemist, let him work in the factory for a time to get accustomed to the process and fully acquainted with the problem, and then send him to a laboratory where the essentials such as gas, water, electricity, etc. already exist and carry out his scientific enquiry there with a small scale plant on some system of payment.

If the problem was of sufficient magnitude, manufacturers might pool their interests and collaborate for the solution of an investigation common to all of their factories or, as in the case of sugar research, Government might supply funds.

The Sugar Committee of the Imperial Council of Agricultural Research has recently sanctioned a grant of Rs. 45,000—spread over a period of 5 years for a scheme of research work on the chemistry of sugar-cane, the intention being to help the breeder to be more effective in his methods and to help agriculturists and cultivators throughout the country to use their product properly.

In problems of provincial importance, as, for instance, irrigation problems in the Punjab, a provincial Institute of Research might be contemplated to which other Local Governments could apply for information. Similarly, another province might support a research institute in a different field such as ceramics and assist manufacturers who subscribed to its maintenance all over India.

The question of an all-India Chemical Service has arisen again recently on two separate occasions. In both cases, when a referendum was made to heads of certain Government of India Departments which employed chemists, enquiring whether they would approve of the appointment of a Central Government Chemist and the organization of a Chemical Service of which their chemists would be members, the replies were generally unfavourable. In the first instance, only two departments were prepared to join in such a scheme and the second time, three departments were prepared to consider it, but it is worthy of note that the interests of these three departments concerned were practically entirely confined to analytical work.

At the present time I find myself much more closely in agreement with the minority note of Sir P. C. Rây to the report of the Chemical Services Committee of 1920. He points out that the intention of the chemical research institutes to assist small industries would not be likely to be very effective as the days of small industries are numbered and, in the existing condition of keen competition, powerful combines are likely to swallow up any small industries started with small capital. Again, he thinks that any general industrial research work is perhaps not best done by Government officials who are on terms of continuous service, and in which the question of participating in the profits accruing from discoveries they make is always a vexed question. He feels that industrial research work is best undertaken by men employed on such terms that, while in safe receipt of a living wage, great profits shall only be attained as a result of successful investigation. In other words, that a man should have an interest in the discoveries he makes, that the top of the profession should only be attainable by the most brilliant and that there should be a continued incentive for the chemists to do the finest work of which they are capable.

It is essential that each Provincial Government should give practical support and financial assistance to the development of industry. At present, money is difficult to find and I agree with Sir P. C. Rây that the immediate way to deal with this urgent problem is not to open Central Research Laboratories but to provide technological institutes in every town of commercial importance and to develop our University curricula in such a way that qualified chemists and technologists may be available to industry and industry may be encouraged to appeal to the universities for assistance in their problems on payment or otherwise. Provincial industrial laboratories will follow in course of time.

Some will doubt whether such advisory and experimental work should be done in a university laboratory at all and maintain that the principal, if not the sole function of a university is didactic. In the present stage of India's development, if we argue that it is not within the province of university laboratories to undertake technical analysis, to study industrial problems and to give professional advice to the best of the experience and ability of their staffs and research workers, an immediate public demand will have to go completely unsatisfied and stagnation in the correct control of nascent industries will result.

From our experience in Lahore, it is obvious that business men are showing an increasing desire to seek professional opinion on their chemical problems. In the Panjab University Laboratories we receive a regular stream of questions on industrial subjects and the work is usually undertaken in the first place on the basis of payment by results. In a number of instances we have received considerable fees for technical advice, the highest of which for a single investigation was Rs. 5,000. While some commercial interests have specified that their money shall be devoted to their own concerns, these sums have, in general, been credited practically entirely to a scholarship account, known as The Punjab Chemical Research Fund, which enables us to train annually about ten post-M.Sc. chemists for further scientific work, the process being, in a sense, autocatalytic.

So far as I am aware, there is not a single consultant chemist or public analyst in private practice in the Punjab. In fact there are very few in India at all and I am of opinion that, if the chemical staff of every University in India would place its knowledge at the disposal of the public in a consultant capacity, even without, but preferably with the assistance of laboratory work, a great advance would be made.

On careful consideration, it does not appear that the creation of a Government Chemical Service embracing all branches of the profession is the best way in which to attempt its organization.

Certain subjects might be dealt with by the Local Governments. These would include education, agriculture, industries, public health and provincial analytical work. On the other hand, central laboratories for special purposes are eminently desirable. These are exemplified by the Alipore Test House which might suitably become a bureau of standards for the whole of India, the recently organized central technical control for all laboratories working for the Central Board of Revenue, the Haffkine Research Institute, Bombay, the Agricultural Research Institute at Pusa, the Forest Research Institute, Dehra Dun, the Imperial Institute of Veterinary Research at Muktesar and the Tocklai Experimental Station at Cinnamara for Tea Research. To this may be added provincial laboratories such as the Punjab Irrigation Research Institute at Lahore and the Sugar Research Institute recently approved by the Imperial Council of Agricultural Research, the Indian Institute of Science, Bangalore and others which carry out investigations the results of which will be available for the whole of India.

A very close examination of the technical and administrative difficulties of the proposal for a Chemical Service has caused me to conclude that the only department in which the centralization of chemistry is at all possible would be in the case of appointments dealing with analytical work which have a common basis of qualifications and in the institution of a Central Bureau of Records, information and advice. So far as the former is concerned, it appears to me that it would be possible to form an all-India cadre of analytical chemists serving various departments under the Government of India and that it is probable that the prospects of men who entered this branch of the profession would be improved by the establishment of such a Service. Here again, however, the difficulties are very great unless it can be shown that the work performed by the various members of the service is comparable in nature, responsibility and complexity. As regards the Bureau of Information it is not feasible to suppose that Government could employ senior chemists who would be capable of answering questions on all subjects direct. The intention would be that the Director should have at his disposal complete and exhaustive lists of men available in India who have special knowledge in any branch of chemistry and the work on which they were engaged so that, if certain problems were referred to the Director of that Bureau, he would know exactly what men with specialized knowledge could be consulted in making his report. I also feel that there would be a distinct advantage in having a central laboratory, very well equipped, which would be an all-India bureau of standards and to which analytical and testing work of almost any kind could be sent and dealt with by well qualified chemists, physicists, and engineers on payment of fees. This laboratory would be served by smaller laboratories in important places of which the scope would be limited. It is quite obvious that it is more efficient to maintain one large and very well fitted laboratory manned by a capable staff than it is to spend an equal amount of money on a large number of small laboratories. The functions of the subsidiary laboratories should be confined to general types of analysis to relieve the central laboratory from undue pressure and guarantee speedy disposal of routine samples and not be expected to accept testing work of all kinds.

OUR MOST PRESSING NEEDS.

Before I conclude, I should like to attempt a summary of the most urgent needs of the country which can be influenced by chemistry.

I should place first an increasing attention to the efficiency of our educational system so that it should ensure a sound training in the discipline and fundamental truths of both theoretical and practical chemistry and involve the provision of technological institutions in every city of commercial importance in India. Equally imperative is a continuance of the systematic development of all branches of agricultural chemistry and soil physics accompanied by an initiation of industries to deal with nature's products under systematic and scientific control. Other national obligations are the organization of pharmacy, the introduction of a Food and Drugs Act in every province, the establishment of laboratories for public health, provision for better sanitation and regulated sewage disposal which, properly administered, serves the dual functions of improving public health and fertilizing the land.

I have dealt elsewhere with the inadequate remuneration which is offered to many of our teachers, especially to those who deal with the young mind at its most impressionable age, and have appealed to our governing classes to ameliorate their lot. The tendency in the technical world also is to try to obtain the services of chemists at salaries which would not attract other professional men, for example engineers, of equivalent qualifications. It is not reasonable to expect first class results from second class material and, as in every other walk in life, the best men will go to those who offer the best prospects. The chemist, by the nature of his training is a disciplined and docile worker who carries out his duties conscientiously and without fuss. Hence, not being assertive, he is likely often to be underpaid. I therefore invoke the sympathy of all Governments and all private employers and earnestly beg them to offer to chemists, such terms of engagement and prospects as will enable them to carry out their duties free from anxiety about the necessities of life and without embarrassment concerning the suitable education of their children.

OTHER FIELDS OF INTEREST.

In attempting a survey of the present state and the future prospects of the profession of chemistry in India, I have perhaps undertaken a task beyond my capacity. Many of my audience will feel that I have neglected important fields but this omission is not due to forgetfulness of their importance but to the exigencies of time. None appreciates better than I that my review is incomplete without a wider reference to the importance of bio-chemistry ; I have only had time for a brief mention of agricultural and farming interests, while the cellulose industry, the produce of our forests, the demand of animal husbandry and nutrition and the importance of colloidal chemistry in every phase of animal, plant, and industrial life have only this unworthy and cursory inclusion. Among the other natural resources of this wonderful country on which I have not been able to touch are the vast hidden wealth in coal and petroleum, and in numerous minerals which await your investigation and exploitation. My span has been too brief to deal with building interests and allied industries such as cements, wood preservation, water-proofing materials and countless others it embraces and yet I have given a lengthy discourse. I trust that your patience has not been too sorely tried.

We belong to a profession of unlimited scope and of unfathomed depths of learning. To all of us it must be a matter of personal pride that our work gives us the opportunity not only to add to the nation's wealth but also, as the fruit of our labours, to provide better amenities of life to every one of India's three hundred and fifty million souls.

Section of Chemistry.

Abstracts.

1. The electro-chemical restoration of bronze images.

S. Paramasivan, Madras.

Dr. A. Scott of the British Museum criticises the electro-chemical process of Restoring Bronze images and holds that (1) when a completely mineralised image is subjected to electrolytic treatment, it is reduced to a fine powder and it crumbles away; (2) under this process, there is always a plating of copper on the image; (3) this coating of copper encloses chlorine-containing compounds; (4) considerable knowledge of electro-chemical methods is needed and that the method is too complicated and not safe for use in ordinary museums.

Investigations were carried out to test these conclusions. No plating phenomenon is observed and there is complete absence of chlorine-containing compounds over the image at the completion of the electrolytic restoration.

In restoring completely mineralised specimens (where the object is to reduce the outer crust), all the chemical methods are defective, and the electrolytic method is safer. Though the method is complicated the results are more uniform than under the chemical methods.

2. The influence of (*a*) Charcoal, and (*b*) Sulphur on the decomposition of ammonium nitrate.

M. S. Shah, Ahmedabad.

The decomposition usually starts in presence of charcoal at about 169·5°, the melting point of ammonium nitrate. Much heat is liberated and the reaction soon becomes violent. The reaction products are: (nitrous oxide, water vapour) carbon dioxide, nitrogen, nitric oxide, nitrogen peroxide, and nitric acid. The latter accumulates in the initial stages of the process and is reduced by charcoal at the end of the reaction evolving much nitrogen peroxide.

Sulphur does not affect the decomposition appreciably below 240°C. Above that temperature the reaction is slightly accelerated and some sulphur trioxide is formed. Sulphur dioxide is evolved only in traces when all the ammonium nitrate has practically decomposed.

3. The interaction between Zinc and aqueous solutions of ammonium nitrate.

M. S. Shah *and* S. S. Desai, Ahmedabad.

A dry mixture of zinc dust and ammonium nitrate ignites when treated with a little water. The reaction has been studied quantitatively with (*a*) varying amounts of zinc dust, and (*b*) varying concentrations of ammonium nitrate solution. The heat of reaction has been measured accurately in each case.

4. Removal of Titanium from impure specimens of Niobium.

S. G. Kiri *and* K. R. Krishnaswami, Bangalore.

Existing methods for the separation of mixtures of niobium and titanium are tedious and difficult to carry out.

The method described consists in converting the mixed oxides into their respective potassium complex oxalates and fractionally recrystallizing them. Satisfactory results have been obtained.

The difficulties of the colorimetric hydrogen peroxide method for estimation of small quantities of titanium in presence of niobium and the spectrographic method employed for the purpose are fully described.

5. The properties of Cobaltous Oxide prepared at different temperatures.

T. S. Suratkar, S. M. Mehta, *and* Mata Prasad, Bombay.

One of the authors had previously studied the properties of nickelous oxide prepared at different temperatures and had shown the importance of these results in the separation of nickel from nickel-copper matter.

The present investigation contains the results of a similar study of the properties of cobaltous oxide prepared at different temperatures. It has been found that fairly pure sample is obtained by heating cobalt carbonate above 900°C. The oxide contains active oxygen the amount of which decreases as the temperature of preparation is raised. Also with an increase in the temperature of preparation of the oxide, the colour of the oxide changes from yellow to brown, and its density and electric resistance increase while the catalytic activity in the decomposition of H_2O_2 and the solubilities in sulphuric and hydrochloric acids decrease. The decrease in solubility in sulphuric acid is not so remarkable in the case of cobalt oxide as in the oxide of nickel.

6. The compounds of Dimethylglyoxime with Cobalt Chloride.

P. R. Rây, Calcutta.

Feigl and Rubinstein (*Annalen*, 1923, **433**, 186) have described the preparation of a green compound in acetone solution from cobaltous chloride and dimethylglyoxime. The exceptional stability of the compound, which does not react with any characteristic reagent for cobalt or dimethylglyoxime, led them to assume that it represents a case of strong cobaltous complex with a co-ordination number four. The chlorine atoms lying outside the complex zone were found to act readily with silver nitrate. They also observed that the substance in aqueous solution gives an acid reaction owing to hydrolysis. From a study of the magnetic susceptibility and other physical and chemical properties of the compound, it is now shown that the substance is really a cobaltic complex, and not cobaltous, as suggested by Feigl, Paneth, Thilo, Dübsky, and Brychta. Some new derivatives of the compound have also been prepared and studied.

7. Preparation of Thorium and Cerium Nitrates from Indian Monazite sand.

M. S. Patel *and* S. G. Deo, Bombay.

Fractional precipitation methods for the preparation of thoria from other rare earths has been tried with ammonium hydroxide and sodium carbonate. Digestion of the rare earth oxalates with ammonium acetate has been tried. Digestion of sand with different volumes of concentrated sulphuric acid for varying periods is being tried to find out optimum condition of complete digestion.

8. Preparation of Alumina and Aluminium Sulphate from Indian Bauxite.

M. S. Patel, G. E. Ogale, *and* P. V. Paranjpe, Bombay.

Samples of Bauxite from various localities have been analysed. The solubilities of Al_2O_3, Fe_2O_3, and TiO_2 in acids have been determined. Heating of bauxite at 110° prior to acid treatment has been found to affect the solubility of the above components. All the samples contain silica. In some of the samples of bauxite, silica is in chemical combination. Fusion with sodium carbonate gives better results than digestion with caustic soda. The effects of moisture and presence of organic matter in the mineral have also been studied. Action of sulphur dioxide in presence of water under different conditions is being studied.

9. Sodium Carbonate and Bicarbonate from efflorescent natural soda.

M. S. Patel *and* P. S. Rao, Bombay.

Samples of natural soda from various localities in the Bombay Presidency have been analysed. The study of the systems Na_2CO_3, $NaHCO_3$, NaCl and Na_2CO_3, $NaHCO_3$, NaCl, Na_2SO_4 at 29°, 33°, 40°, 60°, 65°, and 80°C. is being carried out with useful results.

Simplification of the above systems by converting $NaHCO_3$ into Na_2CO_3 by passing steam into the mixture has been tried. A study of the natural process as it takes place in the soda fields has also been made. The results so far obtained show that under proper conditions of temperature and concentration it will be possible to obtain fairly pure sodium carbonate for industrial purposes from efflorescent natural soda.

10. The action of Hydrogen Sulphide on Chromates. Part III. Potassium Dichromate.

H. B. Dunnicliff, Lahore.

In the intermediate stage, a brown precipitate containing $(CrO_2)_x$ is formed. Thiosulphate is first developed in the precipitate and this passes into the alkaline liquid phase. Sulphide is absent from the liquid so long as any chromate ion is present. So long as any hydrogen ions are present, some tetrathionate is formed by the oxidation of thiosulphate but none is formed when the solution is alkaline. This tetrathionate is ultimately converted into thiosulphate and sulphur by the action of potassium sulphide. Thus the final products are (*a*) a precipitate containing chromium hydroxide, co-ordinated chromium thiosulphate in which the ratio of ionic to co-ordinated (S_2O_3) is 2 : 1 and sulphur, and (*b*) potassium polysulphide (K_2S_3) and thiosulphate in solution. Sulphate is absent.

11. The action of Hydrogen Sulphide on Potassium ortho- and metarsenites.

H. B. Dunnicliff, Lahore.

An apparatus is described in which an attempt is made to determine the exact composition of the sulphide of arsenic, As_2S_3, xH_2S which separates from strong solutions.

12. Complex Oxalates of Niobium, Tantalum, and Titanium.

D. S. N. Murthi, S. G. Kiri, *and* K. R. Krishnaswami,
Bangalore.

Russ (*Z. anorg. Chem.*, 1902, **32**, 42) prepared potassium niobium oxalate and assigned to it the formula $3K_2O \,.\, Nb_2O_5.\ 6C_2O_3 \,.\, 4H_2O$. The authors have repeated the work under modified conditions and obtained the same compound as well as another stable hydrate.

They have not been able to obtain potassium tantalum oxalate having a definite composition as the preparations contained varying proportions of oxalic acid.

13. Decomposition of Sulphur Dioxide in electric discharge due to alternating fields of low frequency.

S. S. Joshi *and* K. K. Sharma, Benares.

The apparatus resembled the familiar Siemens Ozoniser. Even though the ionisation space was about 3 mm. wide, the decomposition was sensible with such low pressures as less than 10 cm. Hg by voltages of the order of 10,000. The progress of the decomposition is represented by pressure-time curves. It has been found that the rate of the change at a constant applied potential diminishes as the gas pressure is increased and that it increases by increasing the applied potential with constant gas pressure. The final mixture consists of unchanged SO_2, free O_2, SO_3 and a grey white deposit part of which is free sulphur. This substance absorbs moisture when exposed, does not fume, and gave negative results when examined for persulphate.

14. Equilibrium in the system: Sodium Sulphite-Sodium Thiosulphate-Water.

S. G. Kiri *and* K. R. Krishnaswami, Bangalore.

After carrying out preliminary experiments in order to ascertain the most suitable form of apparatus and conditions for analysis, the composition of the equilibrium mixtures obtained at various temperatures were determined. The results are discussed.

Determinations were also made of the solubility of sodium thiosulphate in sulphite solutions of various concentrations at different temperatures and the results obtained are discussed.

15. The decomposition of Chromates at high temperatures.

V. T. Athaval, Bangalore.

1. The vapour pressure curve of lead chromate shows breaks at 650°, 854°, and 920°. The latter two correspond with the melting points of the compounds $Pb_7Cr_2O_{13}$ and Pb_2CrO_5 (Jæger and Germs, *Z. anorg. Chem.*, 1919, **119**, 155).

2. The vapour pressure curve of strontium chromate (m.p. with decomposition 1160°) up to 1400° was studied in a molybdenum wire wound furnace and shows three breaks at 945°, 1257°, and 1375°. These correspond with 50, 66·6, and 75 per cent. decomposition according to the equation $2SrCrO_4 = 2(SrO), Cr_2O_3 + 3O$; the corresponding intermediate compounds being (*A*) $4SrO$, $2CrO_3$, Cr_2O_3, (*B*) $3SrO$, CrO_3, Cr_2O_3, and (*C*) $8SrO$, $2CrO_3$, $3Cr_2O_3$. *A* and *B* are decomposed by acetic acid giving

insoluble residues of Cr_2O_3 and SrO, Cr_2O_3 respectively. *A* and *B* have been isolated by heating strontium chromate in a high vacuum at 1000° and 1200°.

3. At 1200° in a vacuum, barium chromate decomposes to 4BaO, $2CrO_3$, Cr_2O_3.

16. A rapid volumetric method for the estimation of Nitrites.

K. M. Pandalai *and* G. Gopala Rao, Waltair.

An iodometric method for the estimation of amounts of nitrites within $\pm 0{\cdot}25\%$ depending on the reaction $2HNO_2 + 2HI = 2H_2O + I_2 + 2NO$ is described. The liberated nitric oxide tends to be oxidized to nitrogen peroxide in the presence of air and the nitrogen peroxide thus formed dissolves and liberates more iodine from the acidified potassium iodide. Hence the results for the nitrite will be variable and the following procedure is formulated: About 20 c.c. of the nitrite solution is taken, 4 gms. of sodium bicarbonate added, and then 5 c.c. of a 10% potassium iodide solution and a little starch solution. Now a rapid stream of carbon dioxide is bubbled through this reaction mixture for about ten minutes to eliminate oxygen. After acidifying with 10 c.c. of 0·5 *N* oxygen-free sulphuric acid, iodine is titrated against standard thiosulphate solution. The carbon dioxide liberated from the bicarbonate present will expel the nitric oxide as soon as it is formed.

17. The Electrometer valve.

D. N. Mehta *and* S. K. Kulkarni Jatkar, Bangalore.

The paper describes the use of an electrometer valve (with a grid current of about 10^{-14} amp. and grid insulation resistance of 10^{15} ohms and having a working slope of 0·08 mil. amp. per volt) resistance coupled to valve of ordinary type as a null instrument in measuring the potentials of glass and antimony electrodes.

18. Isolation of the Mercury lines in the violet and the ultraviolet.

B. K. Vaidya, Bangalore.

Light filters for the isolation of the groups of strong, photochemically active radiations from the mercury arc lamp, are described from time to time by various workers. Not all of these are however satisfactory when such of the factors as, stability towards light, fair amount of monochromatism, convenience in handling and easy procurability together with maximum transmissibility, are considered. In view of these difficulties the existing filters for the violet and the ultraviolet lines of mercury are modified or completely revised, and the following are recommended.—

Aqueous solution of cobalt sulphocyanate for the 404 $\mu\mu$ line; Wratten ultraviolet filter, or aqueous solutions of either chromium sulphate or cobalt sulphate for the lines at 365 $\mu\mu$; aqueous para-nitrosodimethylaniline combined with cobalt sulphate for the line 334 $\mu\mu$; potassium chromate in water with either Chance's u.v. glass or a solution of cobalt sulphate for the group of lines at 313 $\mu\mu$, and chlorine gas at six atmosphere pressure with either cobalt sulphate or a mixture of cobalt sulphate and nickel sulphate for the radiations at 254 $\mu\mu$.

Concentrations and thicknesses of the various solutions, and the transmission data as recorded by the thermopile, as also the photographs of the mercury arc through these filters, are given.

19. An X-ray investigation of the crystals of *p*-hydrazotoluene.

Mata Prasad *and* M. P. Lakhani, Bombay.

The crystals of *p*-hydrazotoluene belong to the monoclinic prismatic class. From rotation photographs about the a-, b-, and c-axes the dimensions of the unit cell have been determined.

The oscillation photographs taken about the a- and the b-axes show that (hol) planes are halved when h is odd and (010) is also halved. These halvings correspond to the space group C^5_{2h} with Γ_m Bravais lattice. The number of molecules required by the space group is four and the number of molecules calculated from the dimensions of the unit cell and the density of the crystals being also four, the molecules are asymmetric.

A probable arrangement of molecules inside the unit cell has been suggested.

20. An X-ray investigation of the crystals of anthranilic acid.

M. R. Kapadia *and* Mata Prasad, Bombay.

The crystals of anthranilic acid occur in two modifications. Both of which belong to the Rhombic-bipyramidal class. They differ in the axial ratios and the density. From an x-ray investigation of the first modification (density 1·367), dimensions for the unit cell have been determined.

The discrepancies between the value of the axial ratio obtained by Groth have been explained.

The oscillation photographs taken about a- and b-axes gave a series of planes in which planes (hol) are halved when h is odd and (hko) are halved when k is odd. The crystals thus belong to the space group Q^{11}_h. The number of molecules in the unit cell is eight. The molecules of anthranilic acid are, therefore, asymmetric.

21. An X-ray investigation of the crystals of *o*-Nitro Diphenylamine.

Jagdish Shanker *and* Mata Prasad, Bombay.

The substance was prepared by the method described by Goldberg (*Ber.*, 1907, 4545), and was purified by recrystallization from alcohol. Two types of well-defined crystals were obtained by the slow evaporation of an alcoholic solution of the pure substance: (i) hexagonal form, and (ii) rhombic form [Groth (vol. V, p. 49) describes only the first form]. The melting point of both the forms was the same, 77·5°.

The rotation photographs taken about a-, b-, and c-axes by means of a shearer gas tube fitted with a copper anti-cathode were found to be identical in both the forms of the crystals. The dimensions of the unit cell have been determined.

Oscillation photographs about a- and b-axes were taken at an interval of 15°, and the indices of the planes were worked out by Bernal's method (*Proc. Roy. Soc.*, A., 1926, **113**, p. 117). It was found that planes (hol) are halved when h is odd and (hko) are halved when k is odd. Also the planes (100) and (010) are halved. These halvings correspond to the space group Q^{11}_h. The number of molecules required by the space group is eight. The molecules, therefore, possess some elements of symmetry. A probable arrangement of molecules inside the unit cell has been suggested.

22. The magnetic properties of the system Sulphur-Selenium.

S. S. Bhatnagar *and* P. L. Kapur, Lahore.

The magnetic property of a non-metallic binary system, sulphur-selenium, with respect to concentrations up to 10 atoms per cent. of selenium has been studied. The susceptibility-concentration relationship provides a curve and not a straight line which would have been the case if it obeyed the additive law of Pascal for mixtures. The maximum deviation occurs at a point where sulphur and selenium exist in a definite ratio and it appears to be due to the formation of sulphur-selenium complex.

23. On the theory of liquids.

T. S. Wheeler, Bombay.

If $\frac{\mu}{r^m}$ is the force between two molecules with the distance r between their centres, μ being independent of temperature, and if δ, the diameter of the molecule is taken to be given by

$$\delta=K_1\sqrt[3]{V},$$

where K_1 is a constant and V is the volume of 1 mol of the liquid, then it is shown that at low temperatures the surface tension γ is given by

$$\gamma=K_2V^{\frac{m+1}{3}}.$$

If m be put equal to 11, we obtain

$$\gamma=K_2V^4$$

which is the parachor equation.
From this, making use of the Gibbs-Helmotz equation, it can be shown that

$$L_i=8{\cdot}24\gamma V\frac{2}{3}\left(1+\frac{7T\alpha}{3}\right)$$

where L_i is the internal heat of vapourization in calories per g.-mol, and α is the coefficient of thermal expansion. The application of this equation shows good agreement with observed values.

24. Photo-reduction of Ferric Chloride in Alcohols.

B. V. Mohile *and* Mata Prasad, Bombay.

Photo-reduction of pure anhydrous ferric chloride in ultraviolet light from mercury arc lamp in solution in anhydrous alcohols has been studied. It is observed that the reaction proceeds in two stages.

The reaction in the initial stage follows a zero-molecular order. An equilibrium or a stationary stage is then reached after a certain time, depending upon the concentration of the solution. On further exposure the reaction begins again, the velocity in the second stage being greater than that in the first stage. Experiments are in progress to study the effect of concentration and pH on the course of the reaction.

25. Photolysis of Amides and Amines in sunlight.

K. M. Pandalai *and* G. Gopala Rao, Waltair.

Aqueous solutions of amides are photolyzed when exposed to sunlight in the presence of photo-sensitizers like zinc oxide and titanium dioxide. The first step in the reaction is hydrolysis resulting in the formation of the ammonium salt of the corresponding acid, e.g. from acetamide, ammonium acetate is formed. The ammonia is then oxidized to nitrite if calcium carbonate is present.

Amines are oxidized to nitrite in aqueous solutions when exposed to sunlight in the presence of photo-sensitizers. Here also the first step in the reaction is hydrolysis resulting in the formation of the corresponding alcohols and ammonia. Alcohol is subsequently oxidized to aldehyde and the ammonia to nitrite.

Amides and amines undergo similar changes in the soil which are ascribed to bacteria. The authors suggest that these changes are not entirely due to bacterial action, but that they are also partly photochemical in character.

26. Absorption and dispersion in terpenes.

R. Padmanabhan *and* S. K. Kulkarni Jatkar, Bangalore.

The absorption spectrum of nopinene and sabinene was studied with a Speckkar photo-meter. No band was found in the region where rotation dispersion was anomalous. In the case of nopinene the observer anomaly is apparently due to an impurity having a rotation of opposite sign and high dispersion repeated fractionation having yielded a substance having this property.

27. Surface tensions of aqueous salt solutions.

S. S. Joshi *and* P. K. N. Panikkar, Benares.

It is shown that the surface tension of the solutions tends to be an ionically additive property as the salt concentration is diminished. No accurate relation could be traced between the molecular concentration of the solute and its effect on the surface tension of water. The results obtained show that the increase in the coagulating power of an electrolyte with an increase of its molecular weight cannot be ascribed to the capillary activity of the electrolytes which are studied.

28. A note on the current permeability theories and their application to the action of foreign substances on the permeability of membranes.

A. Nagaraja Rao, Bangalore.

An attempt is made to explain the effects of foreign substances by considering the Sieve theory of Traube, the lipoid theory of Overton and the adsorption and surface tension theories. Changes in the structure of the micelle consequent on the adsorption of the foreign substances have also been explained.

29. Coagulation of colloid Aluminium Oxide by Potassium Chloride solutions.

S. S. Joshi *and* P. K. N. Panikkar, Benares.

Gann (*Kolloid Chem. Beihefte*, 1916, 8, 64) showed that the above coagulations showed *autocatalysis* when examined viscometrically. In order to test the validity of his conclusions, viscosity measurements have been taken by Scrapa's apparatus which does not require a knowledge of the density to evaluate the viscosity. On varying the coagulation concentration, it was found that keeping the colloid content constant, the nature of the viscosity-time curve varied considerably with the coagulation concentration. The Scrapa curve characteristic of autocatalysis was observed only in a very limited number of coagulations and marked viscosity changes with time occurred without any sensible coagulation taking place.

30. Effect of ultraviolet rays on hydrophobe sols.

S. S. Joshi *and* A. S. Nanjappa, Benares.

The relation between viscosity and the coagulation of (i) antimony sulphide sol, (ii) thorium hydroxide sol, and (iii) colloidal manganese dioxide has been studied. The sols were exposed in a quartz vessel to the action of intense ultraviolet light and viscosity measured at definite intervals. No change in viscosity was observed in any case. Change in refractive indices and in absorption spectra of the solutions were measured to study coagulation, but no change in these physical properties was noticed. Sols of gum dammer and gamboge were also exposed but no change in their refractive indices were observed.

31. Kinetics of slow coagulation from the standpoint of Smoluchowski's theory.

S. S. Joshi, Benares.

In a number of communications the author and his collaborators have shown that the actual process of coagulation of polydisperse sols in the slow region is much more complex than that contemplated in the Smoluchowski theory and is not amenable to a simple extension of the theory. Smoluchowski's theory does not take sufficient account of the precise rôle of the post primary particles, a factor involved in the autocatalysis theory of the kinetics of coagulation. One of the chief assumptions of Smoluchowski's theory is that coagulation is only a continued coalescence of the primaries. The evidence accumulated by the author shows that the process of coagulation is discontinuous with respect to time.

Another possibility ignored in the various theories of coagulation is the possible variation in the adsorbability of the coagulating material during coagulation. It is suggested that the change consists of *successive zones of coagulation* and that each such zone is characterized by a sensibly constant electrolytic adsorption. The theoretical utility of this postulate in affording a rational basis for the classification of coagulation into 'rapid' and 'slow' regions and offering a plausible interpretation of the Bödlander limit are discussed.

32. The variations of viscosity during the coagulation of the Antimony Sulphide and Ferric Oxide sols.

S. S. Joshi *and* A. S. Nanjappa, Benares.

The change in viscosity on the coagulation of antimony sulphide and ferric oxide sols has been studied. The antimony sulphide sol was treated with variously concentrated solutions of potassium oxalate, potassium tartarate, thorium nitrate, and potassium chloride; the ferric oxide sol was coagulated by ferric chloride, thorium nitrate and barium chloride. In agreement with previous results the viscosity-time curves show a number of marked discontinuities and in a number of cases a well-defined initial fall. Judged both by the turbidity method and the occurrence of flocculation, coagulation was found to have been taking place in all these cases. In the majority of these experiments, it was found that the viscosity had diminished appreciably during the progress of coagulation, which is remarkable, being contrary to general experience. The concentrations of the coagulants used corresponded to the region of slow coagulation. It is also significant that the electrolyte added contained, in the majority of cases, polyvalent ions of the same charge as the colloid.

33. The variation of the refractive index of colloids subjected to coagulation in the slow region. Evidence for the existence of ‘ Zone of Coagulation ’.

S. S. JOSHI *and* S. JAGA RAO, Benares.

Results are given for the change of the refractive index of colloid manganese dioxide when mixed with aqueous solutions of HCl, $(Li)_2SO_4$, NaCl, NH_4Cl, KCl, $BaCl_2$, $SrCl_2$, $AlCl_3$, $La(NO_3)_3$, $Ce(NO_3)_4$ and $Th(NO_3)_4$. The concentrations of each of these were varied over by wide range. On the whole the refractive index diminished during coagulation due to $Th(NO_3)_4$, $AlCl_3$, NH_4Cl in all the cases observed. With solutions of HCl, NaCl and KCl, at certain stages of coagulation, the refractive index increased beyond the initial value depending upon the concentration of the coagulation. The refractive index always increased during coagulation due to solutions of $BaCl_2$, $SrCl_2$ and $La(NO_3)_3$. In almost all coagulations, a steady state was produced during which the refractive index remained constant over quite long periods.

Evidence is obtained showing that the change is not continuous in respect of time. Coagulation by $BaCl_2$, $SrCl_2$, $Ce(NO_3)_4$, $Th(NO_3)_4$ and $AlCl_3$ revealed the existence of a number of exceedingly well-defined stages during each of which the refractive index remained constant. It is considered that the existence of these stages, each marked by a characteristic refractive index, affords evidence for the theory advanced by Joshi that coagulation is not time-continuous, but occurs through successive zones of coagulation.

34. Variation of viscosity in the mutual coagulation of colloids.

S. S. JOSHI *and* P. K. N. PANIKKAR, Benares.

This has been investigated by the Scarpa's method for coagulation with the ferric oxide sol mixed with colloid (i) antimony sulphide, (ii) manganese dioxide, and (iii) arsenious sulphide. The proportions of the constituents of the mixtures were varied over a wide range. The viscosity-time curves showed definite discontinuities and in some cases an initial fall. In the system ferric oxide sol and arsenious sulphide sol, it was observed that the viscosity never increased beyond the initial value. In a series of coagulations between the sols of ferric oxide and arsenious sulphide viscosity never increased beyond the initial value. A diminution of viscosity through a series of breaks was also observed when there was no coagulation produced in the system. The common notion of viscosity rise during coagulation must be considered as unjustifiable by these and similar results observed in these laboratories.

35. Studies of some physical properties of gels in order to determine their structure. Part IV.

N. A. YAJNIK, D. N. GOYLE, *and* C. L. RAMPAL, Lahore.

Further work on the study of some physical properties of stannic phosphate, acetyl cellulose, thorium phosphate, silica and alumina gels has been carried out. The evidence collected so far points to the crystalline structure of gels with a regular arrangement of crystalline units in the case of elastic gels and an irregular and haphazard arrangement in the case of the non-elastic or brittle gels. The above view with regard to the structure of gels closely approximates to the view of the gel structure advanced by Wm. C. Arsem (*J. Phys. Chem.*, 1926, 306).

36. The relationship between H-ion concentration and adsorption.

N. A. Yajnik, D. N. Goyle, *and* Ishwar Dass, Lahore.

Attempts have been made to investigate whether any relationship exists between the adsorption of dyes (acidic, basic, and neutral) from their solutions by various adsorbants (charcoal, silica, and neutral alumina gels) and the H-ion concentrations of the dye solutions. As a result of these investigations it has been found that—

(1) the H-ions are greatly responsible for the process of adsorption,
(2) in the case of the acidic and neutral dyes there is an increased adsorption of the dye with an increase in the H-ion concentration and vice versa,
(3) in the case of the basic dyes there is a decrease in the adsorption of the dye with a decrease in the H-ion concentration,
(4) on varying the concentration of the H-ions but keeping the concentration of the dye constant, the conclusions mentioned in 1, 2, and 3 have been arrived at.

A mechanism of the phenomena of adsorption is proposed.

37. Adsorption of electrolytes by activated charcoal with reference to its electrical charge.

S. P. Roychoudhury, Calcutta.

Electro-osmotic experiments of negatively and positively charged sugar charcoals in contact with increasing concentrations of HCl, H_2SO_4, NaOH, and NaCl have been carried out. With HCl and H_2SO_4 the negative charge has been found to decrease, while with NaOH and NaCl, the negative charge increases. Positively charged charcoal acquires a negative charge with very low concentrations of HCl and H_2SO_4.

Analytical estimations of the adsorption of HCl, H_2SO_4, and NaOH have been carried out with both samples by different methods.

38. Heat of adsorption of Nitric Oxide by charcoal.

M. S. Shah *and* S. G. Sharangpani, Ahmedabad.

The adsorption of nitric oxide by charcoal has been observed to proceed continuously for a long time accompanied with chemisorption of oxygen (Shah, *J.C.S.*, 1929, 2661). In studying the mechanism of the process, the heats of adsorption of nitric oxide, carbon dioxide, and nitrogen by purified sugar charcoal, which had been previously heated to 900° under a high vacuum, have been accurately measured under varying conditions at 0°C.

In experiments with nitric oxide, it has been observed that—

(i) the evolution of heat is maximum at the commencement of adsorption,
(ii) the evolution of heat is continuous and is proportional to the volume of the gas adsorbed by charcoal if the pressure of the gas is kept constant, and
(iii) the evolution of heat goes on progressively diminishing with time when the adsorption is allowed to proceed with a definite volume of the gas.

In experiments with carbon dioxide and nitrogen, no such continuous evolution of heat is observed since the process of adsorption is complete within a short time.

39. Velocity of reactions in heterogeneous systems, Part II.

D. D. Karvé *and* K. K. Dole, Poona.

The reaction between carbon disulphide and sodium hydroxide was studied further by using neutral solvents, immiscible in water. The velocity was found to be proportional to the carbon bisulphide concentration as well as to the alkali concentration. In the reaction of carbon bisulphide with aqueous alkali, increase in the quantity of the former increases the velocity up to a maximum limit, further increase having no influence.

40. Velocity of reactions in heterogeneous systems, Part III.

D. D. Karvé *and* K. K. Dole, Poona.

The decomposition of benzoyl chloride with water and the hydrolysis of benzoyl acetate with $N/100$ alkali have been studied. In the case of the former reaction, separation of benzoic acid, which is sparingly soluble in water, introduced disturbing factors. When a solvent like xylene was used, the reaction conformed to the monomolecular formula. The hydrolysis of benzoyl acetate gave similar results.

41. The electrical properties of colloidal solutions with reference to the difference between the colloidal solutions of acid substances and of acids in true solution.

J. N. Mukherjee, Calcutta.

Colloidal solutions of insoluble substances which are known from electrochemical data to have a decidedly weak character, behave as very strong (completely dissociated) acids, in a state of colloidal solution. Calculations show that they resemble univalent more than polyvalent completely dissociated acids. They also show the character of a weak partially dissociated acid.

The total neutralizable acid is determined by the specific surface and kinetic factors. Different forms of curves are obtained which show the variation of the hydrogen ion concentration with the dilution.

There is evidence showing the disappearance of hydroxyl ions by chemical combination with anhydride acid molecules as distinct from neutralization of hydrogen ions. It has also been observed that different quantities of the strong bases (e.g. NaOH and $Ba(OH)_2$) are required for the neutralization of the same amount of a colloidal acid.

The thermodynamic assumptions underlying the definitions of degrees of dissociation, dissociation constants and solubilities are not applicable without modification to these colloidal solutions. There is no standard state of reference and no unequivocal definiteness of the total concentration.

42. Difficulties in the measurement of the cataphoretic speed of colloidal particles by the moving boundary method.

J. N. Mukherjee, S. P. Roychoudhury, *and* S. Palit, Calcutta.

In the present paper difficulties met with in the measurement of the cataphoretic speed of colloidal particles by the Moving Boundary Method, other than those directly arising out of the migration of ions under an electric field (e.g. calibration of the tube, separation of the boundary into two layers, free fall of the boundary, movement of colloid through the upper liquid, choice of a suitable upper liquid, constancy of the potential gradient) have been discussed.

The peculiarities of the free fall of the boundary have been discussed and it has been shown that the rate of free fall depends on the nature of the upper liquid, the dilution of the sol and the rate of filling the tube with the colloid. With the ultrafiltrate as upper liquid a ferric hydroxide sol exhibited no free fall. The free fall has been observed even when the differences of density between the upper liquid and the colloid is negligible.

Possibilities of the mechanical mixing, at the boundary of the upper liquid and the colloid, and also of disturbances of the adsorption equilibrium, or of the chemical equilibrium, e.g. changes in degree of hydrolysis on account of the difference in the nature and concentrations of the ions, have been discussed.

On the addition of electrolytes, the potential gradient between the side limbs has been observed to decrease considerably in the case of a ferric oxide sol although the potential drop between the electrodes and the positions of the latter were kept constant. Sometimes a small but regular change in the potential gradient takes place during the passage of the current. These effects probably arise from the adjustment of the concentrations of the two electrolytic solutions in the sense of Kohlrausch's theory of Moving Boundaries or from the changes referred to in the third paragraph above.

43. Surface tension of colloids.

D. N. Chakravarti, Amraoti.

The surface tension of the following colloids has been determined by the methods of Richards, Jaeger, and DuNouy at different dilutions: (1) vanadium pentoxide, (2) mastic, (3) chromium tungstate, (4) zirconium hydroxide, (5) gum dammar, (6) ferric borate, (7) ceric borate, (8) ceric molybdate.

It is observed that the fall of surface tension is very little due to the presence of the dispersed phase specially with the methods of Richards and Jaeger. In some cases a considerable fall in the surface tension is observed when the measurement is made by DuNouy method. It may be concluded also from my results that there is no static or dynamic surface tension of colloids. A mathematical relation has been obtained correlating the surface tension and concentration of the sols.

44. Viscosity variations of colloid Manganese Dioxide in the presence of non-electrolytes.

S. S. Joshi *and* P. S. Rao, Benares.

Experiments are described showing the influence of non-electrolytes on the viscosity variations of coagulating colloids. The non-electrolytes added were solutions of urethane, methyl alcohol, ethyl alcohol, sucrose, and urea of various concentrations. With the exception of alcohol and sucrose, it was generally observed that, in the mixtures where no coagulation occurred, the viscosity remained reasonably constant. Conversely, cases were observed in which variation of viscosity continued in the mixture without any sensible coagulation. This is a striking support of the view, expressed elsewhere, that the determinants of viscosity change and of coagulation, need not necessarily be identical.

45. Variation of the refractive index during mutual coagulation.

S. S. Joshi *and* P. K. N. Panikkar, Benares.

Changes in refractive index have been investigated during the coagulation of colloid manganese dioxide by colloid ferric oxide. The curves obtained are characterized by a final state after which the refractive index does not vary and by discontinuous intermediate stages indicative of a succession of zones of coagulation.

46. The influence of concentration on the viscosity of colloids.

D. N. Chakravarti, Amraoti.

The viscosity has been determined at different concentrations. The equation of Einstein, Hess, Hatschek, and Arrhenius were tested with the experimental results on the following sols: (1) ferric hydroxide, (2) arsenious sulphide, (3) ceric hydroxide, (4) molybdic acid, (5) antimonic acid, (6) mastic, (7) chromium hydroxide, (8) aluminium hydroxide, (9) gum dammar, (10) ferric phosphate, (11) zirconium hydroxide, (12) chromium arsenate, (13) ferric tungstate, (14) ferric arsenate, (15) vanadium pentoxide, (16) chromium tungstate, (17) zirconium hydroxide, (18) ferric borate.

The values of hydrations were calculated for these sols at different concentrations. It was found that the constant 2·5 in the Einstein equation changes from 1·23 to 3·13 with different sols. The dead space 'a' in Hess' equation does not remain constant at different dilutions but is found to be proportional to the viscosity of the sols.

47. Electrical dispersion of liquids.

S. Paramasivan, Madras.

Some interesting phenomena in electrical dispersion of liquids are observed when a current of electricity passes through a system composed of two immiscible electrolytes. Not only the ions but also the electrons and solvated ions are responsible for the transference of electricity from one electrolytic phase to the other.

48. Viscosity of dilute solutions of non-electrolytes.

Balbhadra Prasad, Cuttack.

The logarithm of viscosity plotted against the logarithm of vapour pressure of a liquid gives a straight line. The law connecting viscosity and temperature can be derived from the above generalization. This law is found to be valid for non-associated liquids as found by a number of workers. The author found that as in the case of pure liquids, the logarithm of viscosity of solutions plotted against vapour pressure of the solution concerned or the pure solvent gave a straight line which is for all practical purposes parallel to the line obtained for the pure liquid. Taking this fact and the law connecting vapour pressure of a solution and its concentration into account, an equation connecting viscosity and concentration is derived. This equation is of the form $\frac{\eta}{\eta_0} = 1 + \alpha c$ where η is the viscosity of the solution, η_0, that of the pure solvent and α is a constant which is independent of the solute and temperature.

Experiments carried in this laboratory show that α is independent of temperature.

49. Variability of the numerical value of Traube's factor with changes in the concentration of the examining solution.

A. C. Chatterji, Lucknow.

Freundlich, basing his observation on Langmuir's explanation of Traube's rule, states that the numerical value of the factor is 3·3.

From the experiments given in a previous paper, it has been found that the factor varies with the concentration of a particular pair of any homologous series as well as with the molecular weight of the pair.

In the case of the alcohols, the factor varies from 3·9 to 5, whereas with fatty acids it changes from 3 to 4·2.

It has been found that, both for the alcohols and fatty acids, the factor reaches a maximum value for the ninth or the tenth member and then declines.

50. Applicability of Traube's rule to the phenomenon of wettability.

A. C. CHATTERJI, Lucknow.

The amount of wettability of known substances like naphthalene, anthracene, phenanthrene by watery solutions of fatty acids, alcohols, esters, and amines has been measured by means of a simple apparatus devised in Traube's laboratory.

It has been shown that, in a homologous series, the wettability increases from member to member with increasing molecular weight.

It has been proved that Traube's rule holds good in the following cases :—

(*a*) Wettability of anthracene by solutions of fatty acids.
(*b*) Wettability of naphthalene by alcohol solutions.
(*c*) Wettability of phenanthrene by solutions of esters.
(*d*) Wettability of naphthalene by amines in watery solution.

In the case of fatty acids and anthracene, the well-known Traube Factor has been shown to be about 3, whereas with alcohols it varies. In the case of amines the factor has been found to be 2, which is in agreement with the observations of Freundlich from experiments in an entirely different line.

In the case of higher members of the fatty acids and alcohols the factor becomes somewhat smaller.

51. Effect of polar and non-polar organic compounds on the wettability of a substance.

A. C. CHATTERJI, Lucknow.

The effect of the following organic compounds has been investigated :—

(*a*) Oleic acid, aniline, toluidine, xylidine, phenol, benzyl alcohol.
(*b*) Paraffin (both liquid and solid), carbon disulphide, carbon tetrachloride, chloroform, pentane, hexane.

It has been found that polar compounds in small quantities increase the wettability to a great extent whereas non-polar compounds, even in considerable quantities, produce very little effect.

A new method for determining wettability has been devised.

52. Differential heat of adsorption for silica gel.

N. R. DAMLE, Waltair.

Values of the heat of wetting silica gel by water were determined, the silica gel containing water at different degrees of saturation. Similar determinations were made for alcohol, acetone, carbon tetrachloride and benzene.

From the results the values of heat evolved in the adsorption of these liquids by silica gel up to different degrees of saturation were estimated.

The curves-percentage heat evolved percentage volume of liquid adsorbed, are nearly the same for all polar liquids. The points for non-polar liquids lie approximately on a straight line.

The temperature coefficient of the heat of wetting is negative, the decrease ranging from 3–15% for various liquids.

53. On the resorption of calcium salts through membranes. I. On the influence of the acid radicle on the resorption of calcium salts through membranes.

A. NAGARAJA RAO, Bangalore.

In this series of experiments the diffusion of a number of calcium salts of different organic acids through an animal membrane (intestinal membrane of a pig) has been measured. It has been observed that there is no direct proportionality existing between the size of molecule (without taking into consideration its hydration) and the amount of the substance diffused although several factors other than the mere size seem to play a more important part. The influence of capillary active substances has also been investigated.

54. On the influence of foreign substances on the diffusion of dye-stuffs through gels. I.

A. NAGARAJA RAO *and* B. S. BHEEMA RAO, Bangalore.

Capillary-active and hydrotropic substances are found to alter the diffusion of acids and sugar through membranes and gels. Qualitative experiments using gelatine gels have also led to a similar conclusion in the case of the permeation of dye-stuffs through them. A plausible explanation of the phenomenon would be by a consideration of the changes in the wetting of the pore walls caused by the adsorption of the foreign substance. Factors like swelling, the structure of the micelle leading to an altered pore-size, and the changes in the degree of dispersion of the dye-stuff itself are also to be considered before a conclusive explanation could be offered.

55. Constitution of iodic acid and iodates from Raman spectra.

M. R. NAYAR *and* P. N. SHARMA, Lucknow.

In a previous communication it was pointed out from a study of freezing point depressions and conductivity measurements that iodic acid in concentrated solution is polymerized, but in dilute solutions it has the simple formula, HIO_3, and that iodates are salts of a monobasic acid.

This has now been confirmed by a study of the Raman spectra of solutions of iodic acid of varying concentrations. Raman frequency shifts approximately corresponding to

820	657	357 cms.$^{-1}$
(strong)	(medium)	(medium)

Besides, a few other less prominent lines have been obtained with 5*N* iodic acid. These lines become fainter or totally disappear with dilution, while the water bands become more diffuse and intense. Dilute solutions of HIO_3 and KIO_3 give only one line corresponding approximately to $\Delta\nu = 800$ cms.$^{-1}$

The results are compared and discussed with those obtained by Nisi and by Krishnamurti.

56. The Raman effect in monobasic fatty acids.

G. V. Nevgi, Bangalore.

Raman spectra are obtained for (1) *n*-butyric acid, (2) *iso*-butyric acid, (3) isovaleric acid, (4) *n*-caproic acid, (5) isocaproic acid.

In all the acids, the C-H longitudinal oscillations are represented by three prominent frequencies at 2870, 2910, and 2940. The frequencies 1450 and 1300 are due to the transverse oscillations of hydrogen of the CH_3 and CH_2 group respectively. According to Collins, the frequency 1060 in alcohols represents the oscillation of the carbon chain as a whole, but its appearance in acids also and its agreement with the calculated value (1045) show that it may be due to the aliphatic $C=O$ linkage present in acids, alcohols, and ethers. The frequency 1650 is due to the vibration of carbon and oxygen of the $C=O$ linkage in the carboxyl group.

57. Raman spectra of some substituted benzene derivatives.

G. V. Nevgi, Bangalore.

The Raman effect has been investigated in the following compounds: (1) *n*-propyl benzene, (2) *iso*propyl benzene, (3) *p*-cymene, (4) indene, (5) veratrol, (6) mesitylene.

n-propyl benzene and *iso*propyl benzene are monosubstituted, *p*-cymene—a para-disubstituted, indene and veratrol—ortho-disubstituted, and mesitylene—a trisubstituted benzene derivative. The characteristic benzene ring frequencies in these compounds have been determined.

The results show that all the ring frequencies are reproduced in the monosubstituted compounds. In the disubstituted derivatives, the 1000 frequency is missing in all three and 1030 is observed only in ortho-compounds, with a slightly higher value in veratrol. In the trisubstituted derivative, mesitylene, the two frequencies 1000 and 1030 should be much fainter than in the disubstituted, but they are as strong as in benzene which is evidently due to the symmetrical ring structure common to both benzene and mesitylene. In mesitylene, the frequencies 235, 280, 580, and 1000 appear also as anti-Stokes lines. The frequency 1167 in veratrol is due to the aromatic $C=O$ linkage (calculated value$=$1162).

58. Raman effect in santalols.

B. Sanjiva Rao, Bangalore.

Santalols have been prepared with rotations +6·4° and –45·0° and their Raman spectra compared. The spectra resemble each other though certain interesting differences have been noticed.

59. The structure of molecular compounds.

Balwant Singh *and* H. B. Dunnicliff, Lahore.

The structure of some molecular compounds has been studied by the parachor method. It has been found that one of the components of the molecular compound acts as a donor and the other as an acceptor so that a co-ordinate link is formed between them.

60. The molecular structure of ortho-substituted benzene derivatives in solution.

Balwant Singh *and* H. B. Dunnicliff, Lahore.

The parachors of a number of ortho-substituted benzene derivatives have been determined in benzene solution at 28°C. by the method of Hammick and Andrew (*J. Chem. Soc.*, 1929, 754). The values obtained establish the occurrence of intra-molecular co-ordination which results in the formation of an ortho-ring in each of the compounds.

61. The physical identity of enantiomers. Part I. The rotatory dispersion of enantiomeric camphors and camphoric acids.

B. K. SINGH *and* INDRAMANI MAHANTI, Cuttack.

Campbell (*J. Amer. Chem. Soc.*, 1930, **26**, 560: 1931, **53**, 1661) noticed differences in the numerical values of the rotatory powers of *d*- and *l*-camphoric acids. We have re-examined the rotatory power for 10 different wavelengths ($\lambda=4358$ to 6708) of the carefully purified specimens of *d*- and *l*-camphoric acids and found them to be identical, thus confirming Pasteur's Law of Molecular Dissymmetry. It appears that the discrepancies noticed by Campbell were due to differences in the degree of purity of the two forms.

The camphoric acids obey the law of simple dispersion, whereas camphor follows that of complex dispersion (cf. also Lowry, *J.C.S.*, 1925, **127**, 604).

62. Studies on the Dependence of Optical Rotatory Power on Chemical Constitution. Part XXI. Stereoisomeric Nitrobenzalaminomethylenecamphors and para-dimethylamidobenzalaminomethylenecamphor.

B. K. SINGH *and* S. C. SEN, Cuttack.

Nitrobenzaldehydes (*o*, *m*, *p*) and para-dimethylaminobenzaldehyde have been condensed with aminomethylenecamphors (*d*, *l*, *dl*) in methyl alcoholic solution in presence of anhydrous sodium sulphate. The optically active isomerides (*d* and *l*) have identical rotation and are found to obey the simple dispersion law of Drude,

$$\alpha=\frac{k}{\lambda^2-\lambda_0^2}.$$

From such a study we notice that the molecular rotation of these compounds does not bear any relation to the respective dissociation constants of the benzoic acids derived from the aldehydes employed as shown by Betti (*Gazzetta*, 1923, **53**, 424). The influence of the solvents and of the position isomerides on the rotatory power are also discussed.

63. Studies on the Dependence of Optical Rotatory Power on Chemical Constitution. Part XXII. Rotatory dispersion of isonitroso-*d*-camphor and its sodium derivative.

B. K. SINGH *and* SHEONATH PRASAD, Cuttack.

Rotatory dispersion (α) of isonitroso-*d*-camphor has been determined for various wavelengths (λ) and obeys Drude's Law of Simple Rotatory Dispersion,

$$\alpha=\frac{k}{\lambda^2-\lambda_0^2}.$$

The sodio-derivative is water-soluble and is being studied with a view to determine the difference in the physiological activities of dextro, laevo and racemic forms.

64. Resolution of Co-ordinated Inorganic Compounds into optical isomers. Part I. Resolution of tri-ethylene-diamino-Cadmium chloride, bromide, iodide, and sulphate.

P. Neogy *and* G. K. Mukherjee, Calcutta.

Attempts at resolution of compounds containing ethylene-diamine complexes of divalent metals like Ni, Zn, Cd, etc. have all along failed (Bucknall and Wardlaw, *J.C.S.*, 1928, 2739) though tris-dipyridyl compounds of divalent metals have been resolved by Werner (*Ber.*, 1912, 45, 433), Morgan and Burstall (*J.C.S.*, 1931, 2213). It has been shown here that using *d*-sodio-camphor-nitronate, tri-ethylene-diaminocadmium salts may be resolved. In this way the dextro chloride, bromide, iodide, and sulphate have been prepared and their rotations measured.

65. Resolution of Co-ordinated Inorganic Compounds into optical isomers. Part II. Resolution of tri-ethylene-diamino-zinc chloride, bromide, iodide, and sulphate.

P. Neogy *and* G. K. Mukherjee, Calcutta.

Using *d*-sodio-camphor-nitronate, tri-ethylene-diamino-zinc chloride, bromide, iodide, and sulphate have been obtained in the solid condition. The preparation of these active compounds in solution was reported to the last session of the Congress.

66. Reaction between Ammonia and Methyl Iodide to form Methylamine-hydroiodide.

J. C. Ghosh *and* A. R. Rao, Dacca.

The reaction CH_3I $NH_3{=}CH_3$, $NH_2.HI$ proceeds fairly rapidly at temperatures between 18° to 30°, if the total pressure of the reactants exceeds a limiting value of about 24 cms. When the partial pressures of the reactants were each of the order of 10 cms. or less the reaction takes place with measurable velocity above 325°.

In the low temperature reactions, the reaction came to an end when the pressure inside the reaction tube was of the order of 24 cms. This is explained as being due to the vapour pressure of a liquid film of methyl iodide saturated with methyl-aminehydroiodide at the temperature of the reaction.

The low temperature reaction is a heterogeneous one which takes place in a liquid film of methyl iodide saturated with methylamine hydriodide. An equation for the velocity of transformation has been obtained.

The reaction taking place above 325°, the total pressure of the reactants remaining below about 20 cms., follows the simple bimolecular equation law and the reaction is not influenced by an increase in the ratio surface : volume.

The reaction is sensitive to gaseous catalysts being pronouncedly influenced by iodine vapour.

67. The Kinetics of Heterogeneous Organic Reactions. The Reactions between Organic Halogen Compounds and Solid Inorganic Salts.

M. V. Nabar *and* T. S. Wheeler, Bombay.

The work on the kinetics of the reaction between benzyl chloride or bromide and solid silver nitrate in presence of inert solvents has been continued. The rate of reaction with petroleum ether and ethyl ether is approximately the same, but it is increased in the presence of carbon tetrachloride. In chloroform the reaction is slow. Benzene appears to inhibit the reaction. The best constant is obtained by assuming a bimolecular reaction to take place. The presence of traces of copper decreases the velocity of the reaction greatly.

68. The decomposition velocities of substituted naphthol ethers when heated with halogen acids.

G. B. Kolhatkar *and* V. V. Bapat, Poona.

A large number of the ethers of substituted α and β naphthols dissolved in glacial acetic acid are heated in the presence of an excess of concentrated halogen acids on a boiling water bath. The decomposition velocity was ascertained by estimating either the naphthols liberated during the reaction or the undecomposed ether, after a definite interval of time. The concentration of the halogen acids being in large excess, the velocity constants are determined on the assumption that the reactions are uni-molecular. The values of the velocity constants obtained are fairly constant and thus justify the assumption.

A comparison of the velocity constants reveals the following relations :—

(1) The velocity constants of the substituted ethers of both α and β naphthol have a lower value than those of the ethers of α and β naphthol.

(2) The extent of the lowering in the velocity constants depends (i) on the nature, (ii) on the number, (iii) on the position of the substituting group.

(3) The velocity constant, as in the case of simple ethers, greatly depends on the nature of the halogen acid employed.

69. Influence of acidity and temperature on the hydrolysis of sugars.

A. V. Varadaraja Iyengar *and* S. Rajagopal, Bangalore.

A preliminary study on the effect of pH on the hydrolysis of sucrose has been made. The time and temperature factors also have been considered. The determination of maltose, singly and in combination with sucrose, based on the above factors is in progress. The necessity for the addition of buffers has also been studied. The possible applications of the above in developing an accurate method of estimating carbohydrates in plant extracts and saps is indicated.

70. The Kinetics of Heterogeneous Organic Reactions: A Study of the Benzoin Reaction.

D. R. Nadkarni, S. M. Mehta, *and* T. S. Wheeler, Bombay.

The reaction of pure potassium cyanide on pure benzaldehyde in absence of a third substance gives benzoin but is inhibited in the presence of quinol, alkali halide, and other anticatalysts of the oxidation of benzaldehyde. The kinetics of this reaction has been studied at 100° and at ordinary temperature and found to conform to the equation :

$$\text{Rate of benzoin formation} = K_1 . (\text{benzaldehyde})^2 . (\text{benzoin}) + K_2 . (\text{benzaldehyde})^2 . (\text{potassium cyanide}).$$

It is suggested that the following two reactions take place :

(i) A heterogeneous reaction between solid cyanide and benzaldehyde, the 'cyanidion' on the surface of the solid cyanide being the effective agent. This reaction is inhibited by such negative catalysts as are adsorbed on the solid cyanide.

(ii) A homogeneous autocatalytic reaction between benzaldehyde and a trace of potassium cyanide dissolved in the benzaldehyde, which is uninfluenced by inhibitors as in (i).

The kinetics has also been studied in presence of water, when the rate of (ii) has been found to be unaffected but the reaction with solid cyanide is replaced by a reaction in which 'cyanidions' are involved. In this case reaction (ii) is more rapid at first but with the increase of the amount of water, the dissolved cyanide is extracted from benzaldehyde and hence ceases altogether after a time, reaction (i) alone predominating.

Current theories are discussed in the light of the above results and a mechanism is suggested.

71. The Decarboxylation of β-1-aryl-glutaric acids.

D. B. Limaye *and* Govind R. Kelkar, Poona.

The β-2-methoxy-4-methyl-phenyl glutaric acid obtained by the reduction of the corresponding glutaconic acid was subjected to (1) simple distillation, (2) distillation with lime, and (3) distillation with copper powder. From the resulting products nothing definite has yet been isolated.

Heating with hydrochloric acid in a sealed tube at 125–130° produces no appreciable change. Heating at 150–160°, however, yields 7-methyl-3 : 4-dihydro coumarin-4-acetic acid (m.p. 112–114°) identical with that prepared by Sheshadri by the action of cynacetamide on the coumarin. No decarboxylation has thus taken place in the process.

Methylation of the above acid gives back the original glutaric acid owing to the opening of the pyrone ring.

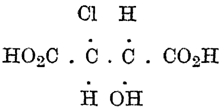
The dihydro-coumarin-4-acetic acid (b.p. 220°/5mm.) when distilled at atmospheric pressure yields a viscous liquid from which acetic acid and 7-methyl-coumarin have been isolated. The latter was found to be identical with that prepared from *m*-cresol and malic acid.

The elimination of acetic acid instead of simple decarboxylation is noteworthy.

72. Studies in Walden Inversion. Interconversion of the Tartaric acids.

V. Anna Rao *and* P. C. Guha, Bangalore.

d-Tartaric acid can be converted by Walden inversion into a minute amount of *l*-tartaric acid through a dichloroderivative. Diethyl *meso*-tartrate does not furnish an optically active product by hydroxylation of any of its halogen derivatives. *l*-Chloromalic acid



$$HO_2C\,.\,\overset{Cl}{\underset{H}{\dot{C}}}\,.\,\overset{H}{\underset{OH}{\dot{C}}}\,.\,CO_2H$$

(where the chlorine and hydroxyl groups are placed similar in position to the two hydroxyl groups in the active tartaric acids) gives with potassium hydroxide *l*-tartaric acid. The sulphito ether of diethyl *meso*tartrate (b.p. 166°/9 mm. ; $D_{20}=1{\cdot}324$; $D_{25}=1{\cdot}323$) yields the *meso*-acid when hydrolysed either by dilute acid or alkali. Based on the results of hydrolysis of sulphito ethers of *meso* and *d*-diethyl tartrate their configurations have been elucidated. Walden inversion of the active menthyl ester of *meso*tartaric acid (m.p. 58-59°, not an oil as recorded by Patterson and Kay, J. 1907, *91*, 707) gave interesting results.

73. An anomalous Benzoin Benzil change.

K. M. Pandalai, Waltair.

Whereas benzoin reacts with aniline and aniline hydrochloride to give (1) benzoin anilide, (2) benzoin anilanilide, and (3) diphenyl indole under different experimental conditions, it has not yet been shown that benzil is also formed together with small quantities of diphenyl at any particular intermediate stage. It has now been found that under suitable conditions benzil and diphenyl could be isolated from the reaction mixture, the former in good yields. It should be admitted that aniline—aniline hydrochloride mixture has no oxidizing action on secondary alcoholic groups as the effect observed with benzoin could not be duplicated so as to get other similar α-diketones such as cuminil, anisil, piperil, furil, etc. from their corresponding secondary alcohols. This apparently anomalous action may be attributed to the highly tautomeric nature of benzoin as instances of its behaving in several reactions as *iso*benzoin, its enolic tautomer, are not uncommon. There seems to be a distinct relation between the nature of the reaction products and the enolizing power of benzoin and oxidation proceeding through enolic tautomer. Literature on the reactivity of benzoin is given.

74. Photolysis of Aminoacids in sunlight.

G. Gopala Rao, Waltair.

Dilute aqueous solutions of aliphatic α-amino acids decompose when exposed in glass vessels to sunlight in the presence of photo-sensitizers like zinc oxide and titanium dioxide. The products of decomposition are ammonia, carbon dioxide and an aldehyde containing one carbon atom less than the amino acid.

The ammonification of aromatic amino acids proceeds much less readily than those of aliphatic amino acids.

The ammonification of amino acids proceeds in soil and is considered to be entirely due to the action of bacteria and fungi. The results recorded here indicate that ammonification in soils is also photochemical. It has also been found that aqueous solutions of proteins like albumin, casein and gelatin decompose in sunlight under aseptic conditions, with the slow liberation of ammonia.

75. Photoinversion and Photodecomposition in Geometrical Isomers, and the Energy levels of a *cis* and a *trans* molecule.

B. K. Vaidya, Bangalore.

The interconversion of the geometrical *cis* and *trans* isomers in the presence of ultra-violet light is well known. α-β-dibromocinnamic acid is, however, an exception. Both the *cis* and the *trans* forms of this acid are decomposed in light with the production of oily dibromostyrene and carbon dioxide. The electrical conductivity of this pair of isomeric acids also shows a contrast with other geometrical isomers, inasmuch as it does not show any very great variation from one form to the other.

Thus the behaviour of α-β-dibromocinnamic acid is anomalous even when compared with the very similarly constituted α-monobromo acid. The presence of a second bromine atom in the molecule profoundly modifies its character, so far as the stability towards the light is concerned. It is possible that the centre of photoactivity is shifted in this molecule from its normal position in the C=C group to the —COOH group.

The theories of Mullikan and Olson regarding the energy levels of a *cis* and a *trans* molecule are examined in the light of the experimental evidence obtained from the quantum efficiency measurements of the various *cis* and *trans* isomers.

76. Conditions governing the Formation of Geometrical Isomerides. Part I. The Stereoisomeric αβ-Dibromocinnamic acids.

P. Ramaswami Ayyar, Bangalore.

Whereas addition of bromine to β-phenylpropiolic acid yields a mixture of the *cis* (m.p. 100°) and *trans* (m.p. 136°) isomers, in the proportion of about 3 : 2, addition of bromine to the methyl ester of β-phenyl propiolic acid and subsequent hydrolysis of the addition product yields much less *cis* than *trans*, the proportion being approximately 1 : 3.

77. Studies in the Isomerism of the Higher Unsaturated Fatty Acids and their Derivatives. Part II. A new isomeric Oleic acid (Δ8 : 9) occurring in the Fatty acids of the Garcinia Fats.

P. Ramaswami Ayyar *and* J. D. Vasavada, Bangalore.

The substance (m.p. 14-15°; $n_D^{23°} = 1{\cdot}4609$) has been isolated by the fractional precipitation of its lead salt from alcohol and petrol and yields capric acid ($C_{10}H_{20}O_2$) and suberic acid ($C_8H_{14}O_4$) on complete oxidation. Mild oxidation gives a dihydroxy acid, m.p. 121-122°.

78. Isomerism in Chloralides.

N. M. Shah *and* R. L. Alimchandani, Dharwar.

The geometrical isomerism of the chloralides derived from α-hydroxy carboxylic acids has been investigated. Two distinct forms, with sharp difference in m.p., have been isolated from the product of reaction of chloral hydrate with *d*-tartaric acid, *dl*-tartaric acid and lactic acid. In view of these results, the discrepancies of recorded melting points in literature are understandable and can be rectified.

79. Some derivatives of Nitro *iso*butylglycerol (2-Nitro-2-methylol-propandiol-1 : 3). Part II. The triacetyl- and amino-derivatives.

K. C. Pandya, Agra.

The preparation of nitro *iso*butylglyceryl triiodide has not been successful. The following are described : nitro *iso*butylglyceryl triacetate, rhombic crystals, m.p. 76°, amino *iso*butyl glycerol hydrochloride, m.p. 149°, hydrochloride of amino *iso*butyl glyceryl trichloride, m.p. 260° (decomp.) and the free *base*, m.p. 180° (decomp.), amino *iso*butyl glyceryl tribromide hydrochloride, m.p. 220° (decomp.).

Amino *iso*butyl glycerol could not be isolated in a pure condition as it suffered decomposition in contact with air.

80. The action of Thionyl chloride on Penta-erythritol.

K. C. Pandya, Agra.

Penta-erythrite-tetrachloride was obtained by Fecht (*Ber.*, 40, 3888) by the action of phosphorus pentachloride on penta-erythritol at 150°, but it can be obtained in a quick and easy way in very good yield by the action of thionyl chloride in the presence of pyridine. The product agrees in m.p. (96-97°) and is confirmed by analysis.

When thionyl chloride is used alone without any tertiary base, another white crystalline substance is obtained, soluble in alcohol, benzene, chloroform, more in hot chloroform. It melted at 153-4°. The presence of sulphur was found in the compound and analysis (by P. N. Kurien) showed sulphur to be 27·80%. This would accord well with the formula $C_5H_8O_6S_2$ (28·07%S) penta-erythrite-disulphate which has been prepared by Baugault by the action of S_2Cl_2 (*C. R.*, 123, 187).

The disulphate ester is also formed in the presence of ether.

81. A study in the degradation to Succinic acids through γ-butyro-lactones and other reactions of β-Anisyl- and β-Halogen-anisyl glutaric acids.

D. B. Limaye *and* R. G. Chitre, Poona.

Windaus and Klanhardt have developed a method for the identification of β-alkyl substituted glutaric acids by the action of iodine on the silver salts when the γ-butyro-lactones are formed. (*Ber.*, *54*, 581–587).

The method has now been extended to β-4-anisyl-glutaric acid (m.p. 164°).

Instead of the expected lactone, β-3-iodo-4-anisyl glutaric acid (m.p. 161°) was formed. 3-Bromo (m.p. 147°) 3-chloro (m.p. 157°)-4-anisyl glutaric acids also did not react.

However, β-3 : 5-dibromo-(m.p. 211°) 3 : 5-dichloro (m.p. 194°)-4-anisyl glutaric acids gave the corresponding γ-butyro lactones. β-3 : 5-dibromo-4-anisyl γ-butyro lactone (m.p. 98°), 3 : 5-dichloro (m.p. 72°).

The lactones on oxidation gave 3 : 5-dibromo (m.p. 198°) and 3 : 5-dichloro (m.p. 173°)-4-anisyl succinic acids, which have also been prepared by directly halogenating the corresponding succinic acid.

By condensing oxalic ester with diethyl esters of the above glutaric acids, the corresponding diethyl esters of 2-R-4 : 5-diketo-penta-methylene-1 : 3-dicarboxylic acids were prepared. (*Ber.*, 1899, 1932–35). R=4-anisyl (m.p. 123°), 3-iodo-4-anisyl (m.p. 133°), 3-bromo-4-anisyl (m.p. 128°), 3-chloro-4-anisyl (m.p. 126°), 3 : 5-dibromo-4-anisyl (m.p. 168°), 3 : 5-dichloro-4-anisyl (m.p. 165°).

Anhydrides, diethyl and dimethyl esters, semi-anilides phenacyl esters and oxidation products of the above glutaric acid were also prepared.

82. Structure of Benzene.

P. C. Guha, Bangalore.

A new dynamic formula is now proposed according to which all the six carbon atoms of benzene lie in the first phase in one plane and in the second, alternate carbon atoms occupy positions in two parallel planes as suggested in the *Proceedings of the* 19*th Indian Science Congress*, 1932, p. 185. The model in both of its plane and solid phases is symmetrical and is in agreement with orientation results and number of possible derivatives. Oscillation of the carbon atoms, arrangement of bonds in different phases, evidence in support of *para*-linking, non-olefinic nature, etc. are discussed. Last of all are described the essentials from physical points of view, e.g. spectroscopic results, infra-red and Raman spectra, thermochemical data, X-ray and dipole moment.

83. Halogenation, XVIII. Bromination and Iodination of Thymol.

P. S. Varma, Benares.

Attempts have been made to brominate and iodinate thymol under different conditions of temperature, using various solvents and brominating and iodinating agents in the presence or absence of third substances. Experiments have been carried out using such solvents as acetic acid, alcohol, ammonia, alkali hydroxides, acetic anhydride and also in mixtures of two solvents. The brominating agents employed have been liquid bromine, bromine in acetic acid, bromine in aqueous potassium bromide, potassium bromide and potassium bromate. The iodinating agents employed have been iodine in aqueous potassium iodine, iodine in acetic acid and nitrogen iodide in ammonical solutions. Bromo- and iodo-derivatives of thymol have been obtained,

84. Halogenation, XIX. Bromination of Phenanthrene.

P. S. VARMA, Benares.

Bromination of phenanthrene has been carried out by the direct action of bromine in the presence of substances such as nitric acid, nitrosulphonic acid, etc., which have not been tried before, in the dark, in diffused daylight and in direct sun-light at different temperatures. In some cases a very good yield of the bromo-derivatives, better than that obtained hitherto by other methods, has been obtained.

85. Halogenation, XX. Uranium oxide as a Halogen Carrier.

P. S. VARMA, Benares.

Experiments have been carried out on the halogenation of aromatic hydrocarbons and their mono substituted derivatives in the presence of uranium oxide. A good yield of the halogen derivatives has often been obtained. In some cases additive compounds and in others substitution derivatives have been isolated.

86. Finely divided Copper in the reaction of the Sulphur monochloride and Sulphur dichloride with Esters of aromatic Hydroxy acids.

N. W. HIRWE, G. V. JADHAV, *and* Y. M. CHAKRADEV, Bombay.

Neither sulphur monochloride nor sulphur dichloride reacts with methyl salicylate alone. On the addition of finely divided copper to the reaction mixture a solid is immediately obtained, which is Di (3-carbomethoxy-4-hydroxy phenyl) thio-ether.

The reaction takes place also in the presence of cuprous chloride.

87. Reaction of Thionyl Chloride with Esters of Aromatic Hydroxy acids in the presence of finely divided Copper. Part II.

N. W. HIRWE, G. V. JADHAV, *and* Y. M. CHAKRADEV, Bombay.

Methyl *o*-cresotinate and methyl *m*-cresotinate were heated with thionyl chloride in the presence of finely divided copper. A solid was obtained which proved to be a thio-ether. The acids were obtained on hydrolysis of the esters and their constitutions are described. Various salts and other derivatives such as acetoxy, benzoyloxy, methoxy, etc. have also been studied.

88. Reaction of Thionyl Chloride with Esters of Aromatic Hydroxy acids in the presence of finely divided Copper. Part III.

N. W. HIRWE, G. V. JADHAV, *and* Y. M. CHAKRADEV, Bombay.

In extension of the reaction in Part II, methyl resorcylate was chosen. The reaction was so vigorous that no definite compound could be isolated. The reaction was moderated by converting the methyl resorcylate to 4-methoxy methyl salicylate and causing it to react with thionyl chloride in the presence of finely divided copper. A solid was obtained which was hydrolysed to an acid of which the constitution has been described.

Various salts and other derivatives such as acetoxy, benzoyloxy and methoxy are described.

o-Nitro phenol and esters of nitro salicylic acids do not yield the thio-ether under similar conditions. In general it may be stated that groups like OH, OCH_3 and CH_3 accelerate the reaction by their presence, while groups like NO_2 and COOH inhibit it.

89. A new general method for Synthesis of substituted *o*-Aldehydocarboxylic acids.

S. N. Chakravarti, Chidambaram.

The method consists in oxidising a symmetrically disubstituted or symmetrically tetra-substituted naphthalene derivative. The idea is that, whichever benzene nucleus is oxidised, the same phthalonic acid or acids should be obtained under the specified conditions. A number of such oxidations have been successfully tried. 5-Methoxy-phthalaldehydic acid, m.p. 144° has been prepared by oxidising 2 : 6-dimethoxy-naphthalene and also synthesised from known 5-Methoxy-phthalonic acid.

90. The rôle of finely divided Copper in the Action of Thionyl chloride on the Esters of Aromatic Hydroxy acids : The Mechanism of the Reaction.

N. W. Hirwe, G. V. Jadhav, *and* Y. M. Chakradev, Bombay.

The mechanism of the reaction has been studied. First sulphur monochloride is obtained by the action of copper on thionyl chloride. Then sulphur dichloride is obtained by the action of cuprous chloride on thionyl chloride. Sulphur monochloride and dichloride act on methyl salicylate in the presence of copper or cuprous chloride to give a thio-ether. Copper chloride and sulphur dioxide interact regenerating cuprous chloride which keeps the reaction going.

91. Bromination of Binuclear Compounds.

G. V. Jadhav *and* Y. I. Rangawala, Bombay.

Previous work has been extended to the esters of *p*-nitro and *m*-nitro benzoic acids, when mono and di-bromo compounds are obtained according to the conditions of the reactions. The first bromine atom always enters the nucleus which has no nitro group and in the position meta to the carbophenoxy group and the other bromine atom goes para to the first. The bromination of the phenyl and *o*-, *m*-, and *p*-cresyl esters has also been studied. The complete deactivation of the nucleus with nitro groups is interesting.

The position taken up by bromine atom is in accordance with the position taken by a nitro group in nitration. (*Neumann*, *Ber.*, *18*, 3320 ; *ibid.*, *19*, 2020 and 2980.)

92. Nitration. Part VII. Nitration of *o*-Xylene.

P. S. Varma, Benares.

Nitration of *o*-xylene has been carried out under different conditions using nitric acid alone or nitric acid in conjunction with plaster of Paris, acetic anhydride, sulphuric acid, and nitro-sulphonic acid. When nitric acid is used alone, some *o*-toluic acid is also formed. In the presence of other substances, however, only nitro-xylenes are obtained. The best yield of the mono-nitro-derivative has been obtained by using a mixture of fuming nitric and nitro-sulphonic acids.

93. Reduction of 2 : 4-Dinitrotoluene.

P. S. Varma, Benares.

The reduction of 2:4-dinitrotoluene has not been systematically studied before. The authors have tried the reducing action of metallic sodium and methyl and ethyl alcohols, zinc dust and caustic soda, aluminium dust and caustic soda, stannous chloride in hydrochloric acid, tin and hydrochloric acid, zinc and hydrochloric acid, magnesium powder and ammonium chloride solution, zinc-copper couple, aluminium-mercury-couple, alcoholic solution of ammonium sulphide, as a result of which a number of reduction products, amongst which diaminotoluene, 4-nitro-2-aminotoluene, 2-nitro-4-amino-toluene, 2:2′-dimethyl-5:5′-dinitro-azoxy-benzene, 2:2′-dimethyl-5:5′-dinitro-azoxy-benzene and some other products such as 3:3′-dinitro-4:4′ditolyl sulphide, 3-nitro-6-tolyl methyl or ethyl ether, have been obtained.

94. Steric Hindrance in Substituted Phthalic Acids. Part III. The β-monomethyl ester of 3-Nitro-phthalic acid.

P. Ramaswami Ayyar, Bangalore.

The structure of this substance (m.p. 163-164°) has been definitely established for the first time by the regulated heating of its silver salt. A quantitative yield of pure methyl *meta*-nitrobenzoate proves it to be the 1-ester of 3-nitro-phthalic acid.

95. Steric Hindrance in Substituted Phthalic Acids. Part IV. The isomeric Monomethyl Esters of 4-Nitrophthalic acid.

P. Ramaswami Ayyar *and* V. N. Pai, Bangalore.

Pure specimens of two isomeric esters (m.p. 132° and 144°) have been prepared by half-saponification of the pure dimethyl ester as well as by half-esterification of the pure 4-nitro-phthalic acid. The regulated heating of their silver salts respectively yielded pure *para-* and *meta-*nitro-benzoic esters, establishing their structures definitely as the 1-ester and 2-ester of 4-nitro-phthalic acid respectively.

96. Condensation of Ethylene Chlorhydrin with Resorcinol and Derivatives of the Products.

D. C. Motwani *and* T. S. Wheeler, Bombay.

2-Hydroxy-4 (β-hydroxy)-ethoxychalkone prepared from 2-hydroxy-4 (β-hydroxy)-ethoxyacetophenone (I) and benzaldehyde gave two acetyl derivatives, viz. 2-hydroxy-4 (β-acetoxy)-ethoxychalkone (violet ferric chloride reaction) and 2-acetoxy-4 (β-acetoxy)-ethoxychalkone. The latter was converted into the corresponding flavone *via* the dibromide, which on de-ethylation furnished 7-hydroxyflavone. Alcoholic sulphuric acid converted the chalkone into 7-(β-hydroxy)-ethoxyflavanone.

5-bromo-6 (β-hydroxy)-ethoxybenzylidenecoumaranone was prepared from the dibromide of the chalkone.

2-hydroxy-4 (β-hydroxy)-ethoxy-4-methoxychalkone similarly prepared gave also a *mono* (characterised by violet ferric chloride reaction) and a *diacetyl* derivative. The dibromide of the latter can be hydrolysed to 7-β-hydroxy-ethoxy-4′-methoxyflavone. The chalkone of (I) with salicylaldehyde was converted into the pyrrilium salt and then into a ferri-chloride, perchlorate, picrate, and mercurichloride. (I) also condensed with *o*-nitro-benzaldehyde. (I) gave a diacetyl derivative, which on reduction with zinc amalgam gave 2-hydroxy-4-(β-hydroxy)-ethoxy ethyl benzene.

The following are prepared :—acetyl, benzoyl, chloro-derivatives of *m*-methoxy (β-hydroxy)-ethoxy phenylene.

Ethyl resorcinol gave with ethylene chlorohydrin (i) 2-hydroxy-4 (β-hydroxy)-ethoxy ethyl benzene and (ii) 2 : 4-di (β-hydroxy) ethoxy ethyl benzene, identical with the reduction products of the corresponding ethoxy derivatives of resacetophenone.

97. C-Alkyl Resorcinols. Part II. Synthesis of Poly-Alkyl Resorcinols.

R. C. SHAH *and* P. R. MEHTA, Bombay.

A number of polyalkyl-resorcinols have been synthesised with a view to studying the influence of two or more alkyl groups in the resorcinol nucleus on the phenol coefficient.

Resacetophenone by nuclear methylation gave 4-methoxy-3-methyl-2-hydroxy-acetophenone, which, on reduction with zinc amalgam and hydrochloric acid, gave 2-hydroxy-3-methyl-4-methoxy-ethyl benzene. Demethylation of the last compound by hydriodic acid gives 2-methyl-4-ethyl-resorcinol.

4-ethyl-resorcinol obtained by the Clemmensen reduction of resacetophenone gave, by the Hoesch reaction, 5-ethyl-2 : 4-dihydroxy-acetophenone. This on reduction afforded the required 4 : 6-diethyl-resorcinol.

98. C-Alkyl Resorcinols. Part III. Derivatives of 4-ethyl-resorcinol.

R. C. SHAH *and* B. V. SAMANT, Bombay.

The reactions of 4-ethyl-resorcinol are being investigated, with particular reference to preparation of compounds of possible therapeutic value. In addition to many of its simple derivatives, which have been prepared for the first time, a number of interesting compounds like coumarins, the corresponding fluorescein and its dibromo derivative, pyryllium salts, and their colour bases which are soluble in chloroform, have been obtained from 4-ethyl resorcinol or its aldehyde, obtained from it by Adam's zinc cyanide method.

Condensation with formaldehyde in acidic solution gives the methylene compound from which further derivatives have been obtained by acytylation and bromination. Some of these compounds are expected to be of interest from the point of view of their antiseptic property.

99. A Synthesis of 5 : 6-Dimethoxyhomophthalic acid and of some Mono-methoxyhomophthalic acids.

S. N. CHAKRAVARTI *and* M. SWAMINATHAN, Chidambaram.

2-Carboxy-5 : 6-dimethoxy-phenylacetonitrile (m.p. 175°) prepared from 4 : 5-dimethoxy-hydrindone *via* the *iso*-nitroso compound, was hydrolysed to the corresponding acid (m.p. 192°). Similarly, 5-methoxy-hydrindone gave an *iso*-nitroso ketone (m.p. 221°) and a corresponding *nitrile* (m.p. 177°). On hydrolysis, the latter furnished an acid (m.p. 222°) and the *iso*-nitroso compound gave a diketohydrindone (m.p. 152°; related quinoxaline, m.p. 140°). In nitrobenzene solution 6-methoxy-hydrindone (m.p. 109°) is formed in 20% yield by the ring closure of *p*-methoxy-cinnamoyl chloride with aluminium chloride (*cf.*, Perkin and Robinson who record failure). 4-Methoxy-2-carboxy phenyl acetonitrile (m.p. 140°) was prepared from its *iso*-nitroso derivative (m.p. 234°) which, on hydrolysis, gave the *acid* (m.p. 188°). 6-Methoxy-1 : 2-diketohydrindone had m.p. 126° (its quinoxaline, m.p. 156°). Yields obtained in the above reactions averaged over 85%.

100. Chemistry of Imido Chlorides. Part V. Action of Benzanilide-imido-chloride on Phenols in the presence of Aluminium chloride.

R. C. SHAH, Bombay.

It is well known that benzanilide-imido-chloride reacts with sodium derivatives of phenols to give imino ethers.

It is now found that benzanilide-imido-chloride reacts smoothly with resorcinol and orcinol in presence of anhydrous aluminium chloride giving anils of 2 : 4-dihydroxy-benzophenone and 2 : 4-dihydroxy-6-methyl-benzophenone, which are isolated in good yields as the sparingly soluble hydrochlorides. The anils on hydrolysis give the corresponding hydroxy-benzophenones.

α- and β-Naphthols react similarly giving the corresponding anils from which the ketones are obtained on hydrolysis with dilute sulphuric acid.

Phloroglucinol also condenses smoothly, but appears to give the dianil of 2 : 4-dibenzoyl-phloroglucinol, which on heating with water in a sealed tube gives the free ketone.

101. Synthesis of Chloral-salicylamide and related products.

N. W. HIRWE, Bombay.

Chloral is condensed directly with (*a*) salicylamide and (*b*) *o*-methoxy benzamide by heating the mixture on the water-bath. Chloral salicylamide and *o*-methoxy benzamide are obtained. These are further reduced with glacial acetic acid and zinc dust.

The compounds are prepared in order to study the hypnotic properties of the chloral group in conjunction with the antiseptic properties of salicylic acid. The chemo-therapeutic index is under investigation.

102. The Condensation of Benzotrichloride with deactivated Aromatic Nuclei.

A. P. KHANOLKAR, P. S. REGE, *and* T. S. WHEELER, Bombay.

It is known that benzotrichloride readily condenses with phenol and aniline. The reaction is vigorous and difficult to control. It has now been found that if the phenyl nucleus is deactivated by the attachment of groups which act as electron sinks, smooth reaction with the elimination of hydrogen chloride is obtained. Thus acetanilide and formanilide react smoothly; acetanilide gives a compound (m.p. 160°) and a base (m.p. 132°); dihydrochloride (m.p. 222°), benzoyl derivatives (m.p. 163° and 117°). Nitranilines and chloranilines also react smoothly.

The hydroxy-benzoic and naphthoic acids also condense. Thus *m*-hydroxy benzoic acid gives a compound (m.p. 125°) which slowly dissolves in hot alkali and on treatment with mineral acids precipitates a mixture of acids. These acids readily give benzoyl derivatives. Camphoric acid also reacts smoothly. Somewhat surprisingly when benzotrichloride is heated with concentrated formic acid, rapid and smooth hydrolysis to benzoic acid takes place.

103. The Nidhone Process for the Synthesis of 2-Acyl-resorcins. Part II. 2-Acetyl-resorcin.

D. B. LIMAYE *and* D. D. GANGAL, Poona.

In Part I, 2-benzoyl resorcin has been synthesised from resorcin by a set of operations, designated as 'The Nidhone Process'.

The preparation of 2-acetyl-resorcin from acetyl 4-methyl-umbelliferone (m.p. 168°), fixes the position of the entering acetyl group in 4-methyl-umbelliferone as 8.

The 2-acetyl resorcin is characterised by the formation of a dibenzoyl derivative (m.p. 106°) and a dimethyl ether (m.p. 73°), which on oxidation gives successively 2:6-dimethoxy-phenylglyoxylic acid (m.p. 93°), and 2:6-dimethoxy-benzoic acid, a known compound. The dimethyl ether gives a semicarbazone (m.p. 220°) and a phenylhydrazone (m.p. 153°).

Condensation of 2-acetyl-resorcin with acetoacetic ester regenerates the 8-acetyl-4-methyl-umbelliferone.

104. Reactivity of Dimethyldihydroresorcin. Part IV. Compounds with Tetrazonium chlorides.

B. H. IYER *and* G. C. CHAKRAVARTI, Bangalore.

The azo- and oxyazo-compounds obtained by coupling dimethyldihydroresorcin with diazotised mono-amines, proved to be valuable dyes for wool and silk.

With a view to preparing dyes substantive to cotton, dimethyldihydroresorcin has now been coupled with tetrazotised benzidine and *ortho*-tolidine and diazotised *p*-nitraniline. The azo- and oxyazo-compounds thus obtained are described. The mechanism of the reaction is also discussed.

105. Condensation of Acetoacetic ester with Phenolic ethers.

G. R. GOGTE, Bangalore.

The work of Limaye, Gogte, Bhave, and Dixit has shown that ethyl acetone-dicarboxylate reacts with phenolic ethers to yield β-substituted phenylglutaconic acids. The reaction with anisole and acetoacetic ester, in place of acetone-dicarboxylic ester, however, gives a monobasic acid (m.p. 162°, M.W., 300, empirical formula $C_{18}H_{20}O_4$), and appears to have arisen out of two molecules of anisole and one of acetoacetic ester. *o*-Cresol methyl ether also gives a similar product with acetoacetic ester; in the case of *p*- and *m*-cresol methyl ethers, the corresponding 4-methyl-coumarins are obtained.

106. Perkin's Reaction with Glutaconic Anhydrides.

G. R. GOGTE, Bangalore.

In a paper by Limaye, Gogte, and Bhave (in the press) it has been shown that the action of sodium acetate and acetic anhydride on the anhydrides of β-aryl-glutaconic acids, proceeds according to Perkin's reaction, the reaction products being named glutaconyl acetic acids. This structure receives support from the products obtained by their successive hydrolysis with alkali.

In the case of the anhydride of the glutaconic acid from *p*-cresol methyl ether, however, if the reaction is carried out under different conditions, a product is obtained (m.p. 168°) which is quite stable towards alkalis, while the product obtained under normal conditions melts at 129°. This new product is a monobasic acid (M.W., 316, empirical formula, $C_{17}H_{16}O_6$). This new reaction appears to be of general application with β-aryl glutaconic acids of the ortho series.

107. Mercury Acetamide as a Mercurating Agent, Part I. Mercuration of Coumarins.

K. G. Naik *and* A. D. Patel, Baroda.

Mercuration of a large number of α-pyrones led to the following generalisations:—

(*a*) Unsubstituted coumarins give di-hydroxy mercuri-derivatives in positions 6 and 8.

(*b*) Even when the position 5 or 7 is occupied by a hydroxy or amino group, results similar to (*a*) are obtained but a methyl group in position 7 allows only a monohydroxy mercuri-derivative to be formed at 6. When position 6 is substituted, different products are obtained depending upon the nature of the substituent. If it is a hydroxy group, a salt is formed, if it is a methyl group, a monomercuric-derivative results. A nitro group in position 6 is eliminated and a monomercuric-derivative at this position is formed.

(*c*) The presence of a methyl or phenyl group in position 4 does not affect the course of mercuration, i.e. dimercuric derivatives are obtained, but the presence of a methyl group in position 8 gives rise to a monomercurated product.

(*d*) COOEt, COMe, or C_3H_5 in position 3 give di-mercurated products but CO . Ph or $COC_9H_6O_2$ in that position allows monomercuration only.

Thio-coumarin is directly mercurated in alcoholic solution easily.

The foregoing mercury compounds are soluble in dilute sodium hydroxide but are unaffected by dilute hydrochloric acid. Potassium iodide decomposes them and sulphuric acid converts them to sulphato-mercuri compounds.

108. Mercury Acetamide as Mercurating Agent, Part II.

K. G. Naik *and* B. V. Mehta, Baroda.

In alcoholic solution, arylamides of acetoacetic acid and mono-arylamides of malonic ester give anhydrides of hydroxy mercury derivatives of the type $\text{-CO-C}_1\text{H . HgO . Hg . C}_1\text{H-CO-}$ when treated with mercury acetamide at ordinary temperature. In the case of (*a*) ethyl phenyl-malonamate, (*b*) ethyl malon-o-tolylamate, (*c*) ethyl malon β-naphthyl amate, (*d*) ethyl malon 1 : 3 : 4 and 1 : 4 : 5 xylilamates, the reaction was done in aqueous alcohol and products were of the type OH . Hg . CH<.

Both the types were regenerated into the original amides with dilute hydrochloric acid. Sulphuretted hydrogen and ammonium sulphide decomposed them to mercuric sulphide, and potassium iodide liberated an equivalent amount of potassium hydroxide which can be titrated. It seems evident that the linkage between carbon and mercury is a very weak one.

With 10% H_2SO_4, the compounds give sulphato derivatives of the type $\text{-CO . C}_1\text{H-Hg . SO}_4\text{ . HgC}_1\text{H-CO}$.

109. Mercury Acetamide as Mercurating Agent, Part III.

K. G. Naik *and* B. V. Mehta, Baroda.

In boiling aqueous alcohol, mercury acetamide gave compounds of the type $(\text{OH . Hg})_2\text{ . C<}$ when reacted with various arylamides of aceto-acetic acid and malonic acid respectively, e.g. aceto-acetanilide and malon-monophenyl amide, etc.

The properties of these compounds also indicate a weak carbon-mercury linkage since they give a similar series of reactions to those discussed in Part II.

110. Mercury Acetamide as Mercurating Agent, Part IV. Mercuration of Phenols.

K. G. Naik *and* B. V. Mehta, Baroda.

Mercury acetamide reacted with the following phenols in hot aqueous alcohol to give monohydroxy mercuri-derivatives. (1) o-nitrophenol, (2) p-nitrophenol, (3) α-naphthol, (4) β-naphthol, but (5) phloroglucinol gave a trihydroxy mercuric derivative. The position of the entering hydroxy mercuric group is determined by the orientating influence of the already existing substituents. This was established by replacement of the hydroxy mercuri-group by bromine. All the four compounds are soluble in dilute sodium hydroxide but show varying degrees of stability towards dilute hydrochloric acid. Products from (2) and (5) are unaffected by hydrogen sulphide, whilst (3) and (4) are slowly decomposed to mercuric sulphide. Potassium iodide decomposes the product from (4) only, which in presence of carbon bisulphide and sodium hydroxide is converted into β-naphthol-α-mercurimercaptan. The product from p-nitrophenol gave 2-2′-mercuribis 4-nitrophenol when its acetoxy derivative was treated with sodium thiosulphate.

111. Condensation of Glyceryl Chlorhydrin with Resacetophenone and the study of the products obtained.

D. R. Nadkarni, Bombay.

With a view to prepare products which may serve as basic substances for the synthesis of flavones and their derivatives, resacetophenone has been condensed with glyceryl chlorhydrin in the presence of 40% potassium hydroxide. The resulting mono-ether (m.p. 160°) gives a colouration with ferric chloride, so that it seems that the hydroxyl group in the ortho position to the acetyl group remains intact. The ether gives a tri-acetyl derivative and condenses with benzaldehyde in the presence of alcoholic potash to yield the corresponding *chalkone* (m.p. 200°).

112. A Synthesis of Brazilinic acid.

J. N. Rây, P. R. Wadha, *and* S. S. Silooja, Lahore.

The Perkin-Robinson synthesis suffers from the disadvantage that the steps are not unambiguous. In view of the fact that the accepted structure of brazilin is based on the constitution of brazilinic acid, an alternative synthesis has been offered.

The authors have converted 4′: 4 : 5-trimethoxy-2-hydroxy-benzophenone into the 2-nitro-derivative by nitration. Reduction, replacement of the amino group by a cyano group and subsequent hydrolysis gives the 2-carboxylic acid, which when caused to react with sodium chloroacetate in alkaline solution, yields brazilinic acid identical with the natural product.

113. Derivatives of 1-Hydroxy-2-naphthoic acid.

G. V. Jadhav *and* S. N. Rao, Bombay.

The nitration of 1-hydroxy-2-naphthoic acid gives a 3 : 4-dinitrohydroxy acid or 1 : 3 : 4-trinitro-naphthoic acid, depending on the concentration of the acid used. The constitution of these have been determined.

1-Hydroxy-3 : 4-dinitro-2-naphthoic acid gave a substance $C_{21}H_8O_{10}N_4$ by decarboxylation and loss of two molecules of water when acetylation, benzoylation or esterification were attempted. The salts of this acid are described.

The sulphonic group of 1-hydroxy-4-sulpho-2-naphthoic acid was replaced by chlorine or bromine. The salts of the resulting acid are described.

114. Synthesis of Ethyl 2 : 3-diketo-1 : 4-endothio*cyclo*hexane-1 : 4-dicarboxylate.

R. C. Das Gupta *and* P. C. Guha, Bangalore.

The general applicability of the method described in paper No. 118 has been established by the synthesis of ethyl 2 : 3-diketo-1 : 4-endothio*cyclo*hexane-1 : 4-dicarboxylate from the disodium derivative of oxalyl thiodiglycollic ester with ethylene bromide. It is expected that replacement of the carbethoxy groups by hydrogen and the reduction of the carbonyl groups to methylene will lead to the formation of 1 : 4-endothio*cyclo*hexane.

115. Studies in Bridge Formation.

D. R. Mehta *and* P. C. Guha, Bangalore.

Methylene iodide, on interaction with the disodio derivative of Schieber and Missel's ester, gave a *bis* methylene derivative instead of the expected bridge compound, because, on hydrolysis, methylene-*bis*-dimethyldihydroresorcin (*cf. Annalen*, 294, 316) was produced. Therefore, the compound described as ketonopinone (*Current Science*, 1933, August, 53) is methylene-*bis*-dimethyldihydroresorcin.

116. Synthesis of Norpinic acid.

K. N. Gaind *and* P. C. Guha, Bangalore.

As an alternative to Kerr's complicated synthesis of norpinic acid, the following simple process has been evolved.

The tetracarboxylic ester obtained by condensing methylene iodide and chloracetol respectively with the disodium derivative of *iso*propylidene dimalonic ester and methylenedimalonic ester, has yielded norpinic acid on hydrolysis and decarboxylation, the yield being extremely poor. The method for the preparation of *iso*propylidene malonic and dimalonic esters has been improved.

117. Studies in Bridge Formation.

K. N. Gaind *and* P. C. Guha, Bangalore.

Ethyl succino-succinate has yielded interesting bridged compounds with methylene iodide, chloracetol, iodine and carbonyl bromide, the first, second, and fourth compound having the bridge through CH_2 : CMe_2, and CO. With iodine, a substance with a direct para linkage has been formed. The bridged structure follows from molecular weight determination and elementary analysis.

118. Studies in Bridge Formation. Synthesis of Ketonorpinic acid and Ketoapo-pinanedicarboxylic ester.

R. C. Das Gupta *and* P. C. Guha, Bangalore.

'Gaureschi' imide reacts with carbonyl bromide to yield α : α-dicyanoketonorpinimide (I). Five compounds, viz. 1 : 3-dicyano-2 : 2-dimethyl-1-carbamyl*cyclo*butane-4-one-3-carboxylic acid, 1 : 1 : 3-tricyano-2 : 2-dimethyl*cyclo*butane-4-one, α-carbamyl-β : β-dimethyl glutaronitrile, α-cyano-β : β-dimethyl glutarimide, α-carbamyl-β : β-dimethyl glutarimide, constitute an interesting series of degradation products of α : α-dicyanoketonorpinimide in the process of its final conversion into β : β-dimethyl glutaric acid by hydrolysis. Compound (I) yields with sulphuric acid at 105° and 130° respectively the *cis* (II) and the *trans* ketonorpinic acids (III).

The disodium derivative of ethyl acetonedicarboxylate reacting with chloracetol in benzene suspension and at high temperatures yields ethyl ketonorpinate (IV) which is hydrolysed by baryta to the *cis* acid (II).

A new method has been devised for the synthesis of 1 : 3-bridged *cyclo*-hexane compounds. The disodium derivative of (IV), reacting with trimethylene bromide, has yielded ethyl ketoapopinane dicarboxylate.

119. Chemistry of Imido-chlorides. Part IV. Condensation of Benzanilideimido-chloride with urethanes: A new Synthesis of 2-phenyl-4-oxy-quinazolines.

R. C. SHAH *and* M. B. ICHAPORIA, Bombay.

The sodium derivatives of urethane and substituted urethanes condense with imido-chlorides derived from acylamines in suspension in ether. Phenyliminobenzyl urethane, an oil, formed from benzanilideiminochloride and urethane, gives high melting products with hydrazine, phenylhydrazine, etc. which serve for its characterisation. The action of heat converts it into 2-phenyl-4-oxy-quinazoline of settled constitution. Similarly methyl and acetyl urethane furnish the corresponding quinazolines.

Benz-α- and β-naphthanilido imidochlorides condense with ethyl urethane giving α- and β-napthyl iminobenzyl urethanes which are transformed by heat into 2-phenyl-7 : 8-benz-quinazoline (m.p. above 300°) and 2-phenyl-5 : 6-benz-quinazoline (m.p. 295°–298°).

120. The Unsaturation and Tautomeric Mobility of Heterocyclic Compounds. Part V. The Benzoxazole System.

R. D. DESAI, R. F. HUNTER, *and* A. R. K. KHALIDI, Aligarh.

It has been found in accordance with the views expressed in earlier parts of this series (Hunter, *J. Chem. Soc.*, 1930, 125 and later) that the benzoxazole system exhibits the greatest similarity to the benzthiazole system (Hunter, *J. Chem. Soc.*, 1926, 1385 and later) as regards the tautomeric mobility and behaviour on bromination of the 1-amino, 1-anilino, 1-hydroxy, and 1-thiol derivatives.

121. The Unsaturation and Tautomeric Mobility of Heterocyclic Compounds. Part VI. The β-Naphthathiazole System.

R. D. DESAI, R. F. HUNTER, *and* M. A. KUREISHY, Aligarh.

The β-naphthathiazole system behaves analogously to the α-naphthathiazole system studied by Hunter and Jones (*J. Chem. Soc.*, 1930, 941); the heterocyclic ring exhibiting strikingly aromatic characteristics in the mobile derivatives.

122. The Formation and Stability of Polybromide Derivatives of Heterocyclic Compounds. Part IV. 5-Methyl and 5 : 5-Dimethyl-ψ-thiohydantoins.

BASHIR AHMAD, R. D. DESAI, *and* R. F. HUNTER, Aligarh.

The ψ-thiohydantoins examined by Farooq and Hunter (*J. Indian Chem. Soc.*, 1932, 9, 545) contain two potentially mobile hydrogen atoms belonging to the keto-enol complex, and the effect of replacement of these by methyl groups on the behaviour of certain ψ-thiohydantoins towards bromine in inert solvents has been examined. The experiments recorded in this paper indicate that the effect of the keto-enol system is negligible as far as perbromide to bromo-substitution hydroperbromide transformations are concerned.

123. The Directive Effect of Substituents on the Cyclisation of Substituted s-Diarylthiocarbamides. Part IV. *p*′-Substituted-*p*-cyano-*s*-diphenylthiocarbamides.

M. Omar Farooq *and* R. F. Hunter, Aligarh.

In all the cases examined (R=Me, I, Br, Cl, F), cyclisation takes place on the nucleus opposite to the point where the *meta* directive cyano group is situated. This is in accordance with the general view that *meta* substitution is essentially a residual effect produced by the disappearance of free affinity from the *o*-*p*-positions in an aromatic nucleus.

124. Studies in Heterocyclic Compounds. Part III.

A. C. Sircar *and* S. C. Sen, Calcutta.

This continues the work of Sircar and De (*J. Indian Chem. Soc.*, 1926, *3*, 312) and Sircar and Pal (*ibid.*, 1932, *9*, 527) and was undertaken with the object of studying how the reactivity of the aminohydroxy groups in ortho-amino phenol is influenced by the introduction of a compact heterocyclic nucleus in its molecule and also how, in compounds containing two dissimilar heterocyclic rings in their molecules, the properties of the different heterocyclic nuclei are affected by each other. 2-Hydroxy-3-amino-phenazine (Ullmann and Mauthner, *Ber.*, 35, 4308) was chosen as the starting material and attempts have been made to introduce various types of new heterocyclic rings *via* the amino hydroxy groups situated in the ortho position. It has now been found that, unlike *o*-amino phenol, 2-hydroxy-3-aminophenazine is not so well adapted for the formation of heterocyclic compounds. Evidently the already existing azine ring in the molecule of 2-hydroxy-3-aminophenazine strongly militates against the otherwise easy reactivity of the *o*-amino hydroxy group.

125. A synthesis of 4-Hydroxy-quinoline-3-carboxylic acid.

R. C. Shah *and* V. R. Heeramanek, Bombay.

In continuation of previous work the authors have now synthesised 4-hydroxy-quinoline-3-carboxylic acid (m.p. 258–260°) by the condensation of formanilide and malonic ester in the presence of phosphorus oxychloride. Camps (*Ber.*, 1901, *34*, 2703) gives m.p. 261–263°.

126. A synthesis of 2 : 3-Methylene-dioxy-11 : 12-dimethoxy-oxy-protoberberine, an isomer of oxyberberine.

S. N. Chakravarti *and* M. Swaminathan, Chidambaram.

N-*β*-Piperonyl-ethyl-5 : 6-dimethoxy-homophthalimide, (m.p. 223°) obtained by condensing *β*-piperonylethylamine and 5 : 6-dimethoxy-homophthalic acid, was hydrolysed to N-*β*-piperonyl-ethyl-5 : 6-dimethoxy-homophthalamic acid (m.p. 245°). The latter was converted into the methyl ester (m.p. 169-170°). The latter, on treatment with phosphorous oxychloride gave 2 : 3-methylene-dioxy-11 : 12-dimethoxy-oxy-protoberberine (m.p. 230-231°).

127. Preliminary synthetic experiments in the Cytisine group. Part I. Attempted synthesis of Ewin's structure for Cytisine.

S. N. Chakravarti *and* A. Venkatasubban, Chidambaram.

Five unsuccessful methods were made to synthesise cytisine according to Ewin's formulæ. The following results were obtained :—

(i) Nitration of 3-methyl-cinnamic acid was shown to give 2-nitro-3 methyl-cinnamic acid (m.p. 244°), 4-nitro-3-methyl-cinnamic acid (m.p. 251°), and 6-nitro-3-methyl-cinnamic acid (m.p. 224°);

(ii) Oxy-uvitic aldehyde was converted into a mono-Schiff's base (m.p. 161°) and then into 3-methyl-5-aldehydo-6-hydroxy-cinnamic acid (m.p. 212°), which was converted into the ester (m.p. 129°), and then into the hydrazide ;

(iii) Attempts were made to effect the internal condensation of 6 : 8-dimethyl-1 : 2 : 3 : 4-tetrahydro-N-nitroso-quinoline between the 8-methyl and nitroso groups ;

(iv) 8-cyano-6-methyl-quinoline (m.p. 90°), 6-methyl-quinoline-8-carboxylic acid (m.p. 169°), 6-methyl 1 : 2 : 3 : 4-tetrahydroquinoline-8-carboxylic acid (m.p. 190-191°), 6-methyl-N-nitroso-tetrahydroquinoline 8-carboxylic acid (m.p. 138°) were prepared.

Attempts to convert ω-ω-dibromomesitylene to the corresponding dialdehyde were unsuccessful.

128. A Synthesis of 2 : 3-Methylene-dioxy-11 : 12-dimethoxy-tetrahydro-protoberberine, an Isomer of Tetrahydro-protoberberine, and a Synthesis of 2 : 3 : 11 : 12-tetramethoxy-tetrahydroprotoberberine, an Isomer of Tetrahydro-palmatine.

S. N. CHAKRAVARTI *and* M. SWAMINATHAN, Chidambaram.

2 : 3-Dimethoxy-phenylacetic acid, prepared by an improved method, was condensed with β-piperonylethylamine to 2 : 3-dimethoxy-phenyl-aceto-β-piperonylethylamide (m.p. 108°). The amide was cyclised to 6 : 7-methylene-dioxy-1 (2′ : 3′ dimethoxy-benzyl)-dihydro-*iso*quinoline and then reduced to tetrahydro-*iso*quinoline hydrochloride (m.p. 160°). The formyl derivative of 6 : 7-methylenedioxy-1 (2′ : 3′ dimethoxy-benzyl)-1 : 2 : 3 : 4-tetrahydro *iso*quinoline was converted into 2 : 3-methylene dioxy-11 : 12-dimethoxy-tetrahydro protoberberine, and the latter reduced to 2 : 3-methylene dioxy-11 : 12-dimethoxy-tetrahydroprotoberberine (m.p. 127°). The corresponding protoberberinium iodide (m.p. 252°), chloride (m.p. 220°), and 2 : 3-methylene dioxy-11 : 12-dimethoxy-oxy-protoberberine (m.p. 231°) were also prepared.

Next 2 : 3-dimethoxy-phenyl-aceto-β-veratrylethylamide (m.p. 131°) was prepared by condensing β-veratryl-ethylamine with 2 : 3-dimethoxy-phenylacetic acid, and converted first into the dihydro-*iso*quinoline and then into 6 : 7-dimethoxy-1 (2′ : 3′-dimethoxy-benzyl)-1 : 2 : 3 : 4-tetrahydro-*iso*quinoline (hydrochloride, m.p. 204°). The formyl derivative of the last base was converted into 2 : 3 : 11 : 12-tetramethoxy-tetrahydroprotoberberine (m.p. 163°), through the dihydroprotoberberine.

129. Experiments on the synthesis of Pyrrolo-indolines.

J. N. RÂY *and* S. SILOOJA, Lahore.

The structure of eserine advanced by Barger has received confirmation from the researches of Robinson and collaborators. In the present paper a pyrroloindolenine with the requisite quaternary carbon atom has been synthesised from lævulinic acid. The cyanhydrin of the latter on hydrolysis furnishes a lactonic acid which has been converted *via* its chloride into an anilide. This, on treatment with hydrazine, is transformed into a hydrazide which in turn changes into an azide by nitrous acid. Thermal decomposition of the latter gives a carbimide which furnishes a triacetyl derivative. Ring closure followed by hydrolysis gives noreserimethole which has been isolated as its picrate.

130. Studies in the derivatives of Pyrazolone. Condensation of the Hydrazine salicylic acids with Ethyl aceto-acetate.

N. W. HIRWE *and* B. V. PATIL, Bombay.

With a view to study new antipyretic compounds, it was sought to condense the hydrazino salicylic acids with ethyl aceto-acetate.

3-Hydrazino hydrochloride of salicylic acid was condensed with ethyl aceto-acetate. A solid is obtained with a high melting point.

5-Hydrazino hydrochloride of salicylic acid was similarly condensed. The condensation compound on treatment with glacial acetic acid gives an acetyl derivative.

The hydrazines were prepared from the corresponding nitro acids by reduction, diazotisation and further reduction.

131. Quinoline Derivatives. Part II. Pyrazolo-quinolines.

J. N. RÂY *and* K. S. NARANG, Lahore.

Phenyl methyl pyrazolone condenses with *o*-nitro aromatic aldehydes to give the corresponding arylidene derivatives. These on reduction furnish, in the case of *o*-nitro benzaldehyde, a quinoline with a hydroxyl group attached to the ring nitrogen and, in the case of nitro-veratric aldehyde, a quinoline and, in the case of nitro-piperonal, an open chain aromatic amine. The latter can be converted into a quinoline by simple heating at its melting point. The structure of these products has been determined by a comparison of their absorption spectra at equivalent dilution in different solvents.

132. Extension of Michael's Reaction. Part IV.

T. N. GHOSH *and* P. C. GUHA, Bangalore.

Ethyl acetonedicarboxylate reacts with thiocarbimides to give ethyl 2-arylimino-thiopyran-4 : 6-dione-3-carboxylate. This compound reacts with benzaldehyde to give a bridged thiopyran compound. Ethyl acetonedicarboxylate reacts with phenyl*iso*cyanate to give ethyl $\alpha : \alpha'$-phenylcarbamyl-acetonedicarboxylate, which reacts with aldehydes to give, with the elimination of a molecule of water and two molecules of alcohol, a tricyclic compound.

Ethyl methylenedimalonate reacts with phenyl*iso*cyanate to give α-phenylcarbamido-$\alpha : \alpha' : \alpha'$-tricarbethoxy-N-phenyl-glutarimide. The condensation of various dienes with phenyl*iso*cyanate and carbethoxythiocarbimides are being studied.

133. Extension of Michael's Reaction. Part V.

T. N. GHOSH *and* P. C. GUHA, Bangalore.

The work reported before (1932) has now been extended. Phenyl azocarboxylic ester reacts with the sodium derivatives of ethyl acetoacetate, cyanacetate and acetyl acetone to yield β-N-carbethoxyacetylmethyl-β-phenyl carbazinic ester, β-N-carbethoxycyanomethyl-β-phenylcarbazinic ester and β-N-diacetylmethyl-N-phenylcarbazinic ester respectively. Ethyl azodicarboxylate with sodium acetoacetic ester gives CO_2Et-N(CHAc. CO_2Et)-NH.CO_2Et. The addition compound CO_2Et.NH-NPh-N(Na)-CO_2Et obtained from sodium urethane and phenylazocarboxylic ester is hydrolysed in the presence of acids into urethane and β-N-hydroxy-β-phenylcarbazinic ester which, on treatment with alkali, undergoes ring-closure and gives the potassium salt from which acids liberate the free hydroxy compound. The methyl and ethyl derivatives obtained from the potassium salt by the action of methyl and ethyl iodide respectively are different from the methyl and ethyl esters of phenylcarbazinic acid.

The additive compounds from mesoxalic ester phenylhydrazone PhNH-N=C(CO_2Et)$_2$ with the sodium derivative of acetoacetic, cyanacetic or malonic ester are easily hydrolysed into Ph.NH.NH.CH (CO_2Et).CO_2H which gives an azo compound on oxidation, and phenylhydrazine acetic acid on hydrolysis with alcoholic potash.

134. Formation of Heterocyclic Compounds.

T. N. Ghosh, Bangalore.

By condensing some carbamic acid derivatives with aniline, phenylhydrazine and thiosemicarbazides, some interesting heterocyclic compounds have been synthesised.

135. Alkaloido-cyclic-ureides. Part I.

P. Neogy *and* A. K. Sen-Gupta, Calcutta.

Owing to the presence of imido-hydrogen in proximity to carbonyl groups, alloxan and other cyclic ureides have acidic reactions and would, therefore, be capable of combination with alkaloids. The preparation, properties, rotation and probable constitution of compounds of alkaloids such as quinine, strychnine, etc. with alloxan are described.

136. Studies in Indigoid Dyes. Part IV. 2 : 1-Naphthathiophene-phenanthrene-indigos.

P. C. Dutta, Muzaffarpur.

In continuation of the work of the present author on thionaphthene-phenanthrene-indigos described in Part 1 (*J. Indian Chem. Soc.*, 1932, 9, 99) and 1 : 2-naphthathiophene-phenanthrene-indigos in Part II (in the press), the present investigation was undertaken with a view to study the effect of the position of sulphur in the naphthalene ring on the colour of the naphthathiophene-phenanthrene-indigos. It deals with indigoid dyes obtained by condensing 2 : 1-naphthoxythiophene with phenanthraquinone and its various derivatives. The condensation was mostly brought about by conc. hydrochloric acid in glacial acetic acid solution of the constituents. The compounds described are generally deeper in shade than the corresponding isomeric 1 : 2-naphthathiophene-phenanthrene-indigos. They dissolve in hydrosulphite vat with a yellow or yellowish brown colour from which the original dyes are precipitated by oxidation with air. They are sparingly soluble in organic solvents.

137. Dyes derived from Acenaphthenequinone. Part IV. Indigoid Vat Dyes.

S. K. Guha, Patna.

In continuation of the work of vat dyes reported in Part III of this series (Guha, *J. Indian Chem. Soc.*, 1932, *9*, 423), this paper describes the preparation and properties of a few more such compounds obtained by the condensation of acenaphthenequinone, its chloro, bromo, and methoxy derivative only with 5-methyl-3-hydroxy-thionaphthene (Auwers and Arndt., *Ber.*, 1909, *42*, 541). The beautiful deep scarlet-red shades developed on cotton from an alkaline hydrosulphite vat and on wool from an acid bath from the first three substances are distinctly deeper than those obtained from Ciba Scarlet G and its halogen derivatives (Guha, *loc. cit.*). This result points to the conclusion that the introduction of a methyl-group in the 5-position of the thionaphthene nucleus in Ciba Scarlet G and its halogen derivatives deepens the shade of the colour of the substances.

138. Studies in Indigoid Dyes. Part V.

P. C. Dutta, Muzaffarpur.

The present communication deals with indigoid dyes obtained by condensing 2 : 1-naphthoxythiophene with isatin and some of its derivatives, acenaphthenequinone, 5-nitroacenaphthenequinone, 5 : 6-dinitroacenaphthenequinone, aceanthraquinone and glyoxal and is a continuation of the work described in Part III on idigoid dyes to be published shortly. As expected, the compounds in this series are all brilliantly coloured glistening needles which impart a deep shade on cotton from hydrosulphite vat. On comparison of the colour produced on cotton by these dyes with the isomeric 1 : 2-compounds described in Part III (*loc. cit.*) it has been found that these 2 : 1-compounds produce colour generally towards red and although a deep shade is produced the colour effect is slightly lighter although in the phenanthrene series an opposite effect is noticed.

139. Dyes derived from Acenaphthenequinone and Isatin.

P. C. Dutta *and* Damodar Prasad, Muzaffarpur.

The reaction of 6-chloro-3 : 4-tolylenediamine (Morgan and Drew, *J.C.S.*, 1920, *117*, 784) on ortho-diketones has been further extended and the present communication deals with compounds produced by condensing 6-chloro-3 : 4-tolylenediamine with isatin, acenaphthenequinone and their various derivatives. The chloro-azines thus obtained were subjected to Ullmann's reaction and the corresponding aniline compounds obtained. As in the phenanthrene series the colour changes from yellow or brown to black with the introduction of the anilido group for the chlorine atom.

140. The effect of substituent groups on the coupling of a Diazonium compound.

N. W. Hirwe *and* Miss K. D. Gavanker, Bombay.

3-Diazo-salicylic acid was chosen to study the above effects and was coupled in alkaline solution with (1) phenol, (2) *o*-cresol, (3) *m*-cresol, (4) *p*-cresol, (5) *o*-nitro phenol, and (6) salicylic acid. It was found that, in the first four cases, the new compounds could be obtained, but in the case of the last two no compound could be isolated. This shows that the presence of OH or OCH_3 groups accelerate the coupling, while the presence of the NO_2 or COOH groups inhibits it.

141. Dyes derived from Isatin.

S. K. Guha *and* H. P. Basu Mallick, Patna.

5-Methyl-3-hydroxy-thionaphthene (Auwers and Arndt., *Ber.*, 1909, *42*, 541) condenses with isatin and its various derivatives with the greatest ease. The condensed products come out rapidly and quantitatively on warming the constituents in glacial acetic acid solution in the presence of a little strong hydrochloric acid. The compounds obtained are,—3-indole-, 3(5-chloro)-indole-, 3(5-bromo)-indole-, 3(5-iodo)-indole-, 3 (5 : 7-dibromo)-indole-, 3(5-bromo-7-nitro)-indole-, 3(5 : 7-dinitro)-indole-2′ (5′-methyl)-thionaphthene-indigo.

142. Dyes derived from Phenanthraquinone.

P. C. Dutta *and* Damodar Prasad, Muzaffarpur.

The authors have succeeded in replacing the chlorine atom in 3-chloro-2-methyl-benzophenanthrene by the anilido group by Ullmann's reaction. The azine dyes, obtained by the condensation of 6-chloro-3 : 4 tolylenediamine with various phenanthraquinone derivatives, gave anilido compounds from which it has been found that the anilido group tends to change the colour of the products from yellow or brown to black.

143. Studies on the chemical behaviour of Vitamin B_2.

B. C. Guha *and* P. N. Chakravorty, Calcutta.

The chemical study of vitamin B_2 has been continued. Charcoal, fuller's earth and silica gel have been tried as adsorbents and various methods have been investigated in order to elute the vitamin from the adsorbates. Methyl alcohol with hydrochloric acid has been found to be one of the most efficient extractants. The vitamin is neither inactivated nor precipitated by bromine and is adsorbed by silver bromide. Fractionation by solvents and several precipitants has also been tried, in some cases with encouraging results.

144. Bitter principle from *Tinospora cordifolia.*

V. K. Bhagwat *and* B. V. Bhide, Poona.

Fluckigor (*Zeit. des Oestn. Apoth ver,* 1884, 312) found a trace of berberine in the bitter principle of *Tinospora cordifolia* but did not identify the other constituents. He only found that the material when boiled with dilute sulphuric acid, gave a sugar and lost its bitterness. The hydrolytic product was not obtained in a pure crystalline condition. Three crystalline substances have now been isolated, m.p. 226–228°, m.p. 181-182°, and m.p. 81-82°. The first of these compounds is not a glucoside. When treated with acetic anhydride in the presence of pyridine, an acetyl derivative m.p. 212° is obtained but, when treated with acetic anhydride in the presence of sodium acetate, a compound m.p. 201-202°, is obtained. It absorbs bromine giving a derivative which is readily decomposed by water. Dilute nitric acid gives oxalic acid. Boiling with dilute caustic soda produces a deep blue solution which gives an orange precipitate in the presence of dilute hydrochloric acid.

145. Chemical investigation of Indian Medicinal plants. Part III. The leaves of *Erythrina indica.*

S. N. Chakravarti, M. L. Sitaraman, *and* A. Venkatasubban, Chidambaram.

A complete analysis of the leaves of *Erythrina indica* has been made. An interesting substance, m.p. 83°, has been isolated. This substance does not contain nitrogen and is a relatively inert substance. The leaves contain a mixture of alcohol-soluble alkaloids, from which a crystalline alkaloid, m.p. 117° has been isolated by extracting the alcoholic extract with acetone.

146. The constitution of a colouring matter of the leaves of *Gingko biloba.*

K. C. Gulati, H. S. Mahal, *and* K. Venkataraman, Lahore.

Comparison of the dimethyl ether (I) of a colouring matter, $C_{16}H_{12}O_5$, isolated by Furukawa (1932) from the leaves of *Gingko biloba,* with known trimethoxyflavones derived from anisic acid and a consideration of the orientation of hydroxyl groups commonly encountered in naturally occurring flavones have led us to believe that *bilobetin* (II) is a monomethyl ether of 3 : 7 : 4′-trihydroxyflavone (III). The Robinson reaction between ω-methoxyresacetophenone and *p*-benzyloxybenzoic anhydride gave 3-methoxy-7-hydroxy-4′-benzyloxyflavone, treatment of which with hydrochloric and acetic acids led to the 3-methyl ether (IV) of (III). Similarly from ω-benzyloxyresacetophenone and anisic anhydride and subsequent debenzylation was obtained the 4-methyl ether (V). Neither (IV) nor (V) resembled (II) and the synthesis of the third isomer is in progress. Starting from 2-hydroxy-4-methoxyacetophenone and *p*-benzyloxybenzaldehyde, 7-methoxy-4′-benzyloxyflavanone has been prepared and a new method for the preparation of polyhydroxychalkones and flavanones has been devised.

147. A note on the correlation between chemical structure and pharmacological action of Embelin.

D. D. Kanga *and* K. S. Nargund, Ahmedabad.

An attempt has been made to correlate the chemical structure and pharmacological action of Embelin which Paranjpe and Gokhale have found to be specific against tape-worms. Most anthelmintics hitherto reported belong to the group of phloroglucinol derivatives (Green). According to Hasan and Stedman's formula Embelin does not belong to this group. It has therefore been proposed that Green's principle correlating structure and anthelmintic properties should be extended so as to include derivatives of quinone and hydroxyquinones.

148. High boiling Phenols from Anthracene oil.

S. K. Ganguli *and* P. C. Guha, Bangalore.

The alkali extract of anthracene oil (b.p. above 350°) yielded on acidification viscous tarry acids (yield 6·67%; sp. gr. at 45°, 1.1283), which, on being distilled under highly reduced pressure, gave fractions (90°–10–200/2 mm.) the last few (150°–10–200°) being highly viscous. Isolation of individual components could not be effected by repeated fractionations, fractional precipitation from sodium hydroxide with hydrochloric acid or as derivatives of $HgCl_2$, picric acid, etc.

Crystalline phenacyl-ethers have, however, been obtained from alcoholic solution of the sodium salts by reacting with ω-brom-acetophenone. Phenacyl ethers from fraction 160–170° yielded, on repeated fractional crystallisation from hot alcohol, two distinct compounds m.p. 163° and 133°.

149. Chemical investigation of the high boiling bases from Anthracene oil (b.p. 170–350°).

S. K. Ganguli *and* P. C. Guha, Bangalore.

Of the three phenylphenacyl esters reported last year the one melting at 208° appears to be a quinoline or *iso*quinoline dicarboxylic ester.

The fractions b.p. 100–105°/2 mm. and 105–110°/2 mm. give a mixture of yellow crystalline picrates from which after repeated fractional crystallisation under regulated cooling within a range of 10°, it has been possible to isolate six distinct picrates, all of which have been converted into the chlorplatinates possessing sharp m.p. It is claimed that five new bases have been isolated from anthracene oil; the presence of 5:8-dimethylquinoline in it is also established.

150. Low temperature carbonization of Indian coals.

S. S. Ghosh *and* H. K. Sen, Calcutta.

The products of low temperature carbonisation of inferior grade Indian coals at various temperatures are discussed.

151. Extraction and purification of Strychnine and Brucine from Nux Vomica.

M. S. PATEL *and* G. B. RAO, Bombay.

Powdered Nux vomica seeds have been extracted with lime and methylated spirit with 40% redistilled methylated spirit and with alcohol. Other solvents including 1 to 10% HCl have been tried. It has been found that the alkaloid content of extracts increases with the concentration. Extraction with dilute HCl gives about 10% less yield of the alkaloids than that obtained with alcohol but, as the acid extracts only the basic substances, the recovery of the alkaloids from the extracts becomes easier. Removal of fatty material and waxes from the seeds prior to extraction simplifies the acid extraction operation

152. Attempted synthesis of Cantharic Acid. Part III.

V. N. PAI *and* P. C. GUHA, Bangalore.

Methyl *cyclo*-hexan-3 : 6-dione-1 : 2-dicarboxylate was methylated with methyl iodide and sodamide in benzene suspension, when only the 2-methyl derivative was isolated. The copper salt of the latter did not react with methyl iodide even on heating under pressure, and the silver salt could not be prepared on account of the strong reducing action of the ketonic ester on silver nitrate. The potassium salt of the 2-methyl derivative, however, reacts to give a neutral oil, which, from its methoxyl value, appears to be a mixture of the desired C-1 : 2-dimethyl compound and the 2-methyl-6-O-methyl compound in equal proportions.

153. *Iso*asarone.

N. C. KELKAR *and* B. SANJIVA RAO, Bangalore.

The asarone isolated from calamus roots has been found to be a mixture of isomers of asarone. Nearly 30% of the oil has been found to be allyl-asarone (*iso*asarone), which is a liquid. Only solid potash above 200° converts the liquid asarone into the solid asarone (m.p. 61-62°). On treatment of the asarone mixture with mercuric acetate a mixture of glycols was obtained. Allyl-asarone has not till now been known to occur in nature. The properties of the product have been compared with the synthetic *iso*asarone.

154. *Ventha-velichchenna*, the oil from coconut milk.

B. H. IYER, Bangalore.

The milky juice obtained from the kernel of ripe but undried coconut, yields, on heating over a free flame, a colourless or light yellow oil possessing a very agreeable and appetizing odour. Four coconuts yield 135 g. of the oil which is a medicine indigenous to Malabar and is a household remedy for many ailments.

The saponification value of the oil is 232 while that of the mixed acids is 277. On separating the unsaponifiable part of the oil by soxhleting the dried soap with petrol (b.p. 50–60°) a liquid (b.p. 120–140°) with an odour resembling that of a hydrocarbon has been obtained.

155. *Cashew-nut* shell oil and its condensation products.

L. GOPALA RAO, Bangalore.

Various known methods of extracting the oil from the shells without injury to the kernels were examined, and it was found that by treatment of the nuts at 200°, or at 160° after abrading the shells, a large percentage (70–80 per cent.) of the oil can be recovered in a satisfactory condition.

The methods at present adopted in commercial practice are deemed unsatisfactory, if only in point of yield.

The oil (cold-pressed) as also the constituents, viz. anacardic acid and cardol, were examined with a view to ascertain the extent to which prolonged treatment at 200–250° affects the chemical properties and varies the nature of the condensation products.

Anacardic acid condenses with hexamethylene-tetramine very slowly and the resulting resin sets at a temperature above 150°, or at 200° in case of the heated acid. Cardol condenses readily yielding a dark resin which brightens to purple on curing. The cold-pressed oil as also commercial specimens yield satisfactory oil-soluble resins which can be rendered infusible and resistant to drastic chemical action. The main difference between the resins from cold-pressed as against commercial oils lies in the critical hardening temperatures, 120° in case of the pure oil and 200° with commercial oils.

156. Extraction of Saponins from Soap-nuts, *Sapindus trifoliatus* and Soap-pods *Acacia concina.*

M. S. Patel *and* M. C. Laiwala, Bombay.

Soap-nuts have been found to consist on the average of about 58% pericarp and 42% stone. The saponin content of the pericarp is about 6·8%. Various methods are being tried to find out a simple and economic process of extraction. Water, alcohol, and methylated spirit have been tried as solvents. Attempts are being made to separate tannins and saponins by fractional precipitation. Preliminary removal of fats and waxes from the pericarp facilitates the extraction of saponins.

157. *Iso*psoralen from the seeds of *Psoralea corylifolia.*

H. S. Jois *and* B. L. Manjunath, Bangalore.

With *Psoralen* (*Jour. Indian Chem. Soc.*, 1933, *10*, 45) a small amount of an isomeric compound (*Isopsoralen,* $C_{11}H_6O_3$) occurs in the solid material which separates from the oil obtained by the extraction of the seeds of *Psoralea corylifolia* with petroleum. The separation of the two is effected by repeated fractional crystallisations from alcohol and chloroform. *Isopsoralen,* m.p. 141-142° is also lactonic and like *Psoralen* can be crystallised from boiling water. Methyl sulphate gives the methyl ester of *methoxy*-iso*psoralic acid,* from which the free acid was obtained by saponification.

158. The chemical examination of the roots of *Aristolochia indica.* Part III.

S. Krishnaswami, B. L. Manjunath, *and* H. Y. Saranabasappa, Bangalore.

The yellow compound isolated from the roots of *Aristolochia indica* was found to have the formula $C_{15}H_{10}O_7$ (m.p. 276°). It is intensely bitter and is sparingly soluble in most of the usual solvents but can be crystallised from a large quantity of alcohol or glacial acetic acid.

It is readily decomposed by cold concentrated sulphuric acid and methoxy groups are absent. Carbon dioxide precipitates it from dilute alkaline solution but it is not a phenol and cannot be acetylated, benzoylated or methylated.

The alkaloidal constituent of the roots, $C_{24}H_{25}O_4N$ has been subjected to detailed chemical examination.

159. Active principles from the fruits of *Solanum xanthocarpum*. (Bhuringini.)

I. Z. Saiyed *and* D. D. Kanga, Ahmedabad.

The powdered dried fruits were successively extracted with petrol and alcohol.

From the petrol extract a gluco-alkaloid (A) (m.p. 245°) has been isolated. This on hydrolysis gave a sugar which has not been identified and a solid m.p. 165–167°.

The alcohol extract on concentration gave a solid (B) (m.p. 238-239°). The residue after removing (B) was separated into basic and non-basic portions. The non-basic portion after purification gave a crystalline compound (C) (m.p. 217–220°). The basic portion gave two crystalline compound (D) m.p. 265° and (E) m.p. 196°. The substance (E) was one of the products of incomplete hydrolysis of the alcoholic extract, the other product being a sugar. This substance on further hydrolysis gave a sugar and a crystalline compound (m.p. 215–217°).

160. The drying of mango pulp.

M. S. Patel *and* S. D. Agnihotri, Bombay.

Mango pulp has been dried under various conditions of temperature and pressure. It has been found that only the pulp dried at temperatures lower than 55° gives good product. Drying under ordinary atmospheric pressure even at lower temperature discolours the product. Drying under lower pressures at temperatures higher than 55° also gives a darker product. Drying at 50° and under 10 mm. pressure yields a product which is friable and has the natural colour of the pulp as found in the fresh, ripe mango. The rate of moisture absorption by the dried pulp has been studied.

Results show that there is a great possibility for developing the mango pulp drying industry in the Bombay Presidency.

161. Cellulose from rice straw by Pomilio process.

M. S. Patel *and* W. V. Kotasthane, Bombay.

Study of the literature on the production of cellulose by chlorine process has been made. Cellulose content of samples of rice straw available in Bombay has been determined. Straw is being treated with chlorine under various conditions to find the optimum conditions. Further work on those factors that would enable the working out of economics for a semi-commercial plant that could be run by the process will be undertaken.

162. *Cashew-nut* shell oil and its industrial utilisation.

M. S. Patel *and* N. M. Patel, Bombay.

The oil as obtained from the cashew-nut roasters is a black viscous liquid having a peculiar smell. About 60% of the oil is soluble in petroleum ether and alcohol. The residue when extracted with acetone yields resinous material, about 7 to 8% of the oil, melting at 183–185°. The oil also contains iron salts. The iron content of the oil is about 3%. Shell oil from raw nuts has been extracted. Analyses of the shell oil from roasted nuts and raw nuts are given.

163. Preparation of camphor from Pinene.

B. G. S. Acharya *and* T. S. Wheeler, Bombay.

Continuing previous work the yield of pinene hydrochloride from pinene has been increased from 76% to a maximum of 85%. The numerous patents on the production of camphene from pinene hydrochloride have been examined but the maximum yield of 83% of the theory obtained by the use of sodium phenoxide, sodium cresyloxide, and sodium β-naphthoxide has not been improved upon. The conversion to borneol of camphene through bornyl acetate does not give yields better than 64%. However, it seems possible that the conversion of bornyl acetate to borneol may be increased by the use of solid sodium hydroxide.

Quantitative yields of camphor from borneol can be obtained by the use of 50% nitric acid. The overall yield of camphor from pinene is 27%.

Contrary to statements in patent literature, it has not been found possible to convert directly pinene to camphene, or pinene hydrochloride to camphor, but the direct oxidation of camphene to camphor is promising.

Conversion of pinene direct to bornyl acetate is unsatisfactory but conversion *via* bornyl salicylate gives better results, particularly if solid sodium hydroxide is used for the preparation of borneol from the ester. (yield 18·5%.) Attempts to replace salicylic by other acids, e.g. tetrachlorophthalic and oxalic acids have been unsuccessful.

164. Studies on the fumigation of shellac films.

M. VENUGOPALAN, Namkum.

An investigation on the effect of certain industrial gases and chemical fumes on shellac varnish films has been made with a view to improving their properties with respect to water resistance, gloss, adhesion, etc. Hydrochloric acid and sulphur compounds like sulphur chloride, carbon disulphide and sulphur dioxide resulted in improved properties, in that the films were resistant to water and alcohol and possessed a fair degree of gloss and adhesion.

Formaldehyde, ammonia, carbon dioxide, etc. induced definite deterioration in the property of water resistance even though they improve the gloss and adhesion of the dry film.

Films exposed to nitric oxide, chlorine, etc. are considerably affected both in the dry as well as in wet condition after exposure to water.

It is suggested that this method of fumigating the articles coated with varnish, particularly by exposure to the fumes of sulphur chloride and carbon disulphide, might find a useful application for making them durable and weather proof.

165. Methods of preventing the formation of mosses on plastered wall surfaces.

S. K. GHOSE, Arrah.

Exposed wall surfaces of buildings become covered with *funaria*. Methods of preventing their occurrence initially, as well as removing them when once they have appeared, are discussed giving results of experiments in that direction. The use of a 4% solution of copper sulphate in the mixing water is advocated.

166. Prechlorination for algal trouble in drinking water.

P. D. DALVI, Jaipur.

During the hot days of summer, uncovered coagulation tanks developed algæ profusely and imparted smell to the water. This involved the frequent cleaning of the tanks and incurred great waste of water. Addition of bleaching powder to the water in suitable doses stopped the growth almost entirely. A 30-gallon wooden barrel with necessary fittings to mix the bleaching powder and deliver the dose, served the purpose. The treatment, besides stopping algal growth, reduced the load on the filters to a minimum and consequently produced a higher quality of water. The dose of bleaching powder containing 25–30% of available chlorine, was between 1 and 2 parts per million. The cost of treatment was comparatively small.

167. Detection of imperfect circulation of water in pipes.

P. D. Dalvi.

The relation between the iron content, turbidity and total count in piped waters led to the use of these measurements to detect improper circulation of water in service pipes.

A water of imperfect circulation had always a relatively larger iron content and other impurities. A measurement of one of these, especially turbidity (this is done in less than 5 minutes), served to locate such troubles readily.

168. A note on the separation of shellac constituents.

M. Venugopalan, Namkum.

The work of Harries and Nagel on the preparation of several modifications of shellac has been reviewed. During the course of preparing one of their modifications by exposing shellac to the fumes of hydrochloric acid, it has been found that a small portion of shellac was unaltered so far as its fusibility and solubility in alcohol are concerned. This soluble portion could, however, be separated by extracting the HCl-exposed shellac three or four times with alcohol. On examining the alcohol-soluble portion in detail it is found to be identical in composition and properties with the normal ether-soluble resin present in shellac. The residue left after extraction with alcohol was practically colourless and possessed the same properties as pure resin.

The possibility of using this method for preparing pure or ether-soluble resin in commercial quantities without the use of a costly volatile solvent like ether and complicated apparatus has been discussed.

169. Physiological products of the lac insect. Part III. A study of 'Phunky' lac wash liquor.

N. K. Ranga Rao, Bangalore.

Most wash liquors from Northern India employing 'Ari' are rich in nitrogen and 'fats'. In South India and in some North Indian factories not having a surplus brood lac, the raw material is 'Phunky'. A comparative study has been made of the wash liquors. The amounts of water and butyl alcohol-soluble nitrogenous substances have been found to be equal in 'Ari' and 'Phunky' lacs but free tyrosine, which occurs to the extent of 2·5% in 'Ari' lac, is absent from the 'Phunky' lac wash.

The nitrogenous bodies are simple polypeptides as indicated by the low ratio of 'total' to 'amino' nitrogen.

Laccaic acid in the mixture can be isolated as the barium salt.

Feeding experiments indicate that nitrogenous bodies are not suitable for the nutrition of albino rats, and that laccaic acid is excreted unchanged.

170. A note on the use of shellac solutions as a vehicle for pigments.

N. Narasimha Murty, Ranchi.

Shellac solutions are used as vehicles for making quick drying paints. The pigments used and found suitable for incorporation are lithophone, blanc-fixe, chrome yellow, Chinese blue, lamp-black, etc. Copper carbonate was found unsuitable. Though the pigment in shellac paints settled down on storing they could be worked up again. High boiling solvents while improving the paint from the point of view of levelling, have the disadvantage of making the film slow-drying. Shellac paints are best suited for decorative work on wood and paper surfaces. Baked shellac paints on metal surfaces have improved adhesion and water resistance, but are very brittle. A shellac paint on a metal surface serves as a good under-coat for pyroxaline or dammar lacquer.

171. Dilatometric studies in Enzyme action. Part VIII. Hydrolysis of Alanine anhydride.

M. SRINIVASAN *and* M. SREENIVASAYA, Bangalore.

The alkali hydrolysis of the 2 : 5-diketopiperazines dilatometrically studied in the first instance with glycine-anhydride (*Proc. Indian Sci. Congress, Patna,* 1933), has been extended to alanine anhydride. This diketopiperazine, obtained in the racemic form by heating *d*-alanine with glycerol (Balbiano and Trasciati), has been treated with varying strengths of alkali in the dilatometer and the increase in volume accompanying the reaction measured at known intervals. The kinetics of the reaction have also been followed independently by an estimation (Van Slyke) of amino groups. A linear relationship between the release of amino groups and volume change has been obtained except in the initial stages where some abnormalities are observed. This initial abnormal change appears to be dependent upon the strength of the alkali used. The final volume change, as was observed in the case of glycine anhydride, is of the order of 7·5 c.c. per amino group released.

172. A dilatometric study of the papain digestion of proteins.

M. SREENIVASAYA, B. N. SASTRI, *and* H. B. SREERANGACHAR, Bangalore.

Enzymic digestion of proteins can be followed in the dilatometer. It is accompanied by a progressive depression in volume. The kinetics of gelatin hydrolysis by papain and also by papain activated by hydrocyanic acid have been investigated in the dilatometer. The depression obtained by the gelatin-papain-hydrocyanic system is about five times that obtained by a system in which the activator is not employed. The kinetics have been followed simultaneously by a determination of the amino nitrogen at definite time intervals.

173. A new Thermophilic Bacterium for dissolving sugars and hemicelluloses.

G. C. DAS GUPTA, R. N. CHATTERJEE, *and* H. K. SEN, Calcutta.

A thermophilic bacterium has been isolated from horse dung at 55° which appears to be distinct from those of Viljoen and Langwell. Recent culture shows the following characteristics :—

It is short, rod-shaped, non-motile and spore-forming. It measures about 4-5μ in length, and 0·75–0·8μ in breadth, the oval spore being fixed to one end of the rod. The spores are generally found to be about 2μ in length and 1μ in breadth. At 55° it ferments both hexoses and pentoses, and has the power of decomposing cellulose, especially in a modified condition. So far as the rate of fermentation is concerned, its action on hemicelluloses is similar to that on the sugars. At lower temperatures, however, the bacterium has no fermentative reaction.

The products of fermentation are alcohol, butyric acid, formic acid, acetic acid and carbon dioxide. Of the total acid, 30% is butyric, 25% formic, and 45% acetic acid. The yield of alcohol varies from 3·0% in the case of arabinose to about 12·0% in the case of water hyacinth. The technical possibilities of the bacterium have been discussed.

174. Dilatometric studies in the enzymic degradation of proteins.

H. B. Sreerangachar, B. N. Sastri, *and* M. Sreenivasaya, Bangalore.

In a recent communication (unpublished) a study of the kinetics of tryptic digestion of casein and gelatin as followed by the dilatometer and the gasometric method of determination of amino nitrogen has been given and the relation between the dilatometric depression and the amino nitrogen increase has been obtained. In continuation of this work, the carboxyl groups released at different stages of the reaction have been estimated by the alcohol titration method of Willstätter and Waldschmidt-Leitz. The ratio between the carboxyl release and the amino nitrogen is strictly unity only in the case of gelatin. The relation between the dilatometric depression and the carboxyl groups released has been established.

In the case of casein the undigested protein has been estimated at different stages by precipitation with tri-chloracetic acid. The quantity of protein hydrolyzed bears an interesting relationship to the dilatometric depression.

175. The amylase of banana.

B. N. Sastri *and* G. R. Row, Bangalore.

The ripening of the banana is accompanied by progressive disappearance of starch and accumulation of sugars. The mechanism of this process has been a matter of controversy. Tellaries and Bailey claim to have shown the presence of a diastase while Falk and McGuire, and Ranganathan have not been able to demonstrate the presence of the enzyme. A critical examination of the question has revealed that the pulp does not appear to contain any amylase which is confined to the skin. Acetone-treated skin, on extraction with a one per cent. solution of peptone, yields an active preparation of amylase which has been found to hydrolyse banana starch.

176. Urease activity of leguminous seeds on germination.

B. N. Sastri *and* B. A. Sundara Iyengar, Bangalore.

It is generally recognised that, on germination, the urease activity of leguminous seeds is enhanced. Viswanath has shown that the urease activity of *Cajanus indicus* increases on germination. The increased activity may be due to (1) an increase in the concentration of the enzyme, (2) the formation of activators, or (3) an increase in the case of extraction. These possibilities have now been critically examined. It has been shown that the increased urease activity is not due to an absolute increase in the concentration of urease or to the formation of activators but due to the enhanced facility with which the enzyme can be extracted after germination. This conclusion has been confirmed in the case of a number of legumes.

177. Rôle of cyanogenetic glucosides in plant metabolism.

M. SREENIVASAYA, Bangalore.

When activated by hydrocyanic acid papain brings about a further degradation of proteins. This activator is possibly provided by the emulsin hydrolysis of cyanogenetic glucosides occurring in plants and it was of interest, therefore, to obtain experimental evidence in support of this theory. A mixture of papain and emulsin was allowed to act on gelatin to which a small proportion of amygdalin was added. A control experiment in which amygdalin was absent was also conducted. Results show that gelatin digestion is definitely activated in presence of hydrocyanic acid developed by the simultaneous hydrolysis of amygdalin.

178. Amylase from sweet potato.

K. VENKATA GIRI, Bangalore.

A very highly active diastatic enzyme which hydrolyses starch into sugars is present in the sweet potato. Attempts have been made to isolate the enzyme in a concentrated form.

A very active preparation can be obtained from the water extract of the meal obtained from the sun dried material by precipitation with alcohol. The activity of this preparation compares very favourably with that of the diastase preparation obtained from barley malt prepared similarly.

The enzyme acts best in the region of P_H 4·8–6·0 (optimum temperature 50–55°). The temperature coefficients of the reaction of the sweet potato amylase on starch have been investigated between 20–70°. Other properties of the enzyme, including the activation by salts have been investigated.

The inner portion of the tuber has greater amylolytic activity than the surface layers. On dialysing the expressed juice in collodion bags, the activity per unit weight of the dry residue is increased nearly five times.

The change in the amylase content of the tuber on storage and its bearing on the physiological changes taking place in the tuber have been discussed.

179. Digestibility of proteins *in vitro*.

H. B. SREERANGACHAR, B. N. SASTRI, *and* M. SREENIVASAYA, Bangalore.

The proteins from three pulses, *Phaseolus mungo, Phaseolus radiatus* and *Dolichos lablab* have been subjected to tryptic hydrolysis under standard conditions and their relative digestibility has been followed both by the dilatometer and the amino nitrogen determination method of Van Slyke.

180. Studies in the proteins of Indian foodstuffs. The proteins of *Lathyrus sativus*.

Y. V. SREENIVASA RAO, Bangalore.

The chief proteins of *Lathyrus sativus*, popularly known as Khesari, are an albumin and a globulin. The former contains 17·2% of nitrogen and 0·88% of sulphur. The latter contains traces of phosphorus, 16·8% of nitrogen and 0·39% of sulphur. A study of the distribution of nitrogen in the globulin yielded the following results: humin, 0·5; amide, 9·6; basic, 35·7; and non-basic, 54·2% respectively. Cystine was present to the extent of 0·56% and tyrosine, 2·84%. Tryptophane was present in traces.

181. The precipitation of anti-bodies from anti-rinderpest serum.

J. R. HADDOW *and* K. C. SEN, Muktesar.

In a recent paper (*Ind. J. Vet. Sci. and Animal Husbandry*, 1933, 3, 149) a number of methods for fractionating the anti-bodies of anti-rinderpest serum were studied. Since then we have carried out a large amount of work with various serum fractions prepared according to different methods and have tested them on animals susceptible to rinderpest virus. It has been found that alcohol gives a good separation of the anti-bodies at 0°C., and that this fraction can be dissolved in normal saline and used in inoculation work on animals without any appreciable loss of potency. It is also possible to concentrate the anti-serum in this way to about 5 times the original strength. Under certain conditions, a low potency serum can also be concentrated sufficiently to be useful for preventive inoculations.

182. The analysis of *ghee*.

C. B. ALMOULA, Karachi.

It is suggested that for genuine cow *ghee* or cow and buffalo *ghee* the following limits should be fixed for the constants named :—

Reichert Meissl value—not less than 24·0.
Polenske—not less than 1·0 and not more than 3·0.
Saponification value—not less than 224 and not more than 230.
Butyro-Refractrometer reading—not less than 41·0 and not more than 44 at 40°C.

The influence of admixture of (*a*) vegetable product, (*b*) coconut oil, and (*c*) mineral oil on these constants has been determined. The author suggests that vegetable product should be coloured by dye by which it could be identified.

183. Estimation of carbonates in the soil.

T. R. SESHADRI, Waltair.

A simple and rapid gravimetric method is described. The conditions for the complete decomposition of the carbonates without introducing errors due to the presence of soil organic matter or sulphides have been studied using different kinds of soils.

184. The colour of cotton-flowers.

T. R. SESHADRI, Waltair.

A remarkable difference in the pigmentation of the flowers of Cambodia (*G. hirsutum*), Uppam (*G. herbaceum*), and Karunganni (*G. indicum*) has been noticed. The first is very pale (ivory coloured) whereas the other two are golden yellow. It is found that this difference cannot be explained as due to the quality or quantity of the pigments present in the different flowers. Perkin's suggestion that the yellow of flowers is due to the existence of the flavonols in the form of potassium salts is not found to be tenable in the present case. From an examination of different reactions of the aqueous extracts of the flowers, it is shown that the differences could be attributed to co-pigmentation which affects particularly the hydroxyl group in the 3 position.

Section of Zoology.

President :—PROF. P. R. AWATI, B.A. (Cantab.), D.I.C., I.E.S.

Presidential Address.

THE IMPORTANCE OF BIOLOGY IN THE PROGRESS OF CIVILIZATION.

I wish in this address to depart from the usual course of discussing a technical topic in technical terms, and I may be allowed to take the liberty of devoting myself to certain general considerations relating to the subject of biology, which I hold to be of great importance in contemporary India. I am conscious of my own limitations, and I seek your indulgence in overlooking the obvious shortcomings in the presentation of my theme. My only excuse is the very genuine enthusiasm I feel for my subject. I am convinced that the changes I envisage in the programmes of studies in our schools and colleges as well as in our general scientific outlook are inevitable in course of time and I therefore wish to see biology taking her rightful place among sciences.

It is unnecessary for me to emphasize the important part the biological sciences have played and are still playing in the life of human beings in modern civilization. The science of life is seen to be all the more important when we remember that our wealth and prosperity are almost wholly dependent on the success of our agricultural pursuits and their derivative industries, and that our health is being undermined by diseases which can only be eradicated by biological research and effective hygienic organization. Food production, cattle breeding, dairy farming, fruit cultivation, control of pests damaging our crops, and prevention of the diseases of our cattle require a trained body of experts in the various sub-sciences of biology. Indeed, research in biology and practice of social hygiene have already changed the tenor of the major civilizations of the world in many ways ; cholera has been checked ; plague has been brought under control ; malaria has been stamped out in several countries ; yellow fever has been made more or less innocuous. Similarly, the ravages of tuberculosis, diphtheria, sleeping sickness, scarlet fever, enteric, and a host of other diseases can be minimized by clinical as well as preventive measures. These are no mean achievements on the part of biologists, and it is abundantly clear that biology will find ever increasing fields for its application. Some of the foremost thinkers of the world have, indeed, come to believe that the whole trend of modern civilization will be dominated, in the near future, by ideas proceeding from the biological sciences. Biological technique, developed by the co-operation of the entomologist, the mycologist, the bacteriologist, the bio-chemist, the cylologist, and the eugenist, will be extensively applied by human beings to satisfy their diverse desires and to solve their problems.

In spite of the practical and theoretical importance of the science of life, is it not surprising to find the amount of ignorance that is prevalent in our present generation relating to all matters biological ? This want of knowledge must be mainly attributed to the defective courses of instruction in our colleges and schools. The training given under the heading of science in our schools consists exclusively of a mere smattering of physics and chemistry, and the science of life which should introduce, at this stage, the first-hand study of life from nature is entirely neglected, and surely should find a better place in the programme of school studies. Indeed, it has been contended in some educational circles that biology should be made the first science subject in schools because the order of introduction from the complex phenomena of life to the simpler phenomena of physics and chemistry would lead to a better understanding of man's place in the universe. However that may be, it is during the pre-adolescent stage that pupils in schools should be made acquainted with the fundamental principles of biology, revealing the mystery of life, its progressive development, and final decay. It is also during these impressionable years that sex education should be imparted to every pupil, and I am glad to note that, in India, a false sense of prudery will not come in the way of such educational policy. The so-called ills and risks of sex knowledge are largely due to the hush hush attitude so often adopted towards sex phenomena. Biology here again will come to the rescue. It is a matter of curious reflection as to what would remain of art and pure literature if sex were banned in them. The post-war deliverance from the majority of senseless sex taboos as reflected in English literature from Joyce to Lawrence is, I think, partly due to the widespread circulation of biological knowledge in English-speaking countries.

In our colleges again, biology and biological sciences are not given the importance they deserve in the humanistic courses which, of course, are not meant to come under the technical study of such subjects from a purely scientific point of view. Most of our Arts graduates can hardly be said to know anything of biology, much less of its cultural significance and implications. It is but natural that when these graduates become leaders of public opinion, or administrators in charge of public policy for general, economic, or social developments in the country, they are at a loss to bring forward any practical solution of the complex problems of modern State organization. The result is unavoidable; our ministers and administrators grope and blunder in darkness, and become the champions of obscurantism. They need not despair; they have their predecessors elsewhere. We must not forget the authorities who not so very long ago told the scientists what had blood to do with breathing, when they were approached for permission to take small quantities of blood for investigating the problem of difficulty of breathing at high altitudes (3).

I do not wish to muddle the issues. Biology, without a doubt, can and should be studied from different standpoints: (1) Academic and strictly scientific biology; (2) Technological biology with reference to practical problems; (3) General biology and biological principles correlated with the social sciences, in other words, the philosophical aspects and implications of biology. The studies coming under (1) and (3) are hardly independent and should be complementary.

A true appreciation of biological facts and processes should, therefore, be one of the objects of our humanistic studies, whether or not such cultural training be an asset for earning one's livelihood. A student of sociology will, for example, find that the foundations of human society are based on certain fundamental biological principles. The unit in human society, whether considered as an individual, family or a tribe, a nation or a race, has similar counterparts in different animal societies. Such studies should be made on a comparative basis. The underlying principles of the various types of marriage system can be better understood by a careful study of the evolution of sex in the animal world. Controversies with regard to the social bearings of endogamous and exogamous marriages must be in touch with current views on the allied topics of *inbreeding* and *outbreeding* as well as with other biological truths and generalizations. A sociologist advocating eugenic legislation must take count of the laws of heredity as established by experiments on living plants and animals. The study of heredity is ultimately the business of the biologist, whether it is looked at from the Mendelian or other points of view.

The institution of the caste system, which is the bane of the Hindu society, should be examined in its biological significations by comparison with the working of societies of ants and bees. It may have originated from a desire for specialization of different sections of the body politic in different activities of trade or craft, but the issue whether this rigid and therefore inelastic social stratification can be maintained or is desirable, requires socio-biological as apart from purely ethical or economic considerations. Dogmatic assertions about inheritance of specialized aptitudes in defence of the caste system are biologically untenable, though it is probable that environment and education may be determining factors in confining talents of a particular kind within a certain group or caste. We must however learn by examples, all the more so, when we recollect the fate that overtook, in ancient geological times, the races of over-specialized creatures. The course of evolution is teeming with many such discarded experiments, and unless the Hindu society consciously guards against such risks, there is no reason to suppose why it should not meet with ultimate extinction.

Biology has many contacts with the subject of economics. The University of London has recently instituted a special Chair of Social Biology in its famous school of Economics. This goes to show the many-sided developments and ramifications of our subject. A modern economist must necessarily and constantly refer to man as an animal, that is to say, to his psychological and biological phenomena in order that he may effectually direct us in our economic reconstruction. A great number of our modern industries are apparently applications of biological knowledge for the production of commodities for social uses and purposes. Control and organization of labour,—which appear to be the stumbling block of the capitalist system,—will often raise biological issues of considerable importance. In fact, any industrial project for the uplift and betterment of society at large cannot ignore the fundamental messages of the biological sciences, and if we go against biological laws, knowingly or unknowingly, we are sure to suffer the ill consequences of such action unless they are consciously counteracted.

A study of biology may become fruitful even in such subjects as theology and scriptural interpretation. Dr. Rele, a medical practitioner of Bombay, has written an interesting book on Vedic lore giving, as I understand, a novel interpretation of the Vedic gods as symbols of biological phenomena. It is not for me to discuss the great systems of Indian philosophy and scientific thought as influenced by concepts of biology. Those who are interested in the history of Indian thought have only to consult among many others that outstanding work, 'The Positive Sciences of the Ancient Hindus', by Sir Brajendranath Seal.

By the foregoing considerations of the intellectual and scientific value of biology, I do not mean to imply that an expert knowledge of the subject should be the objective of every citizen in a country. All that I mean to say is that a proper understanding of the elementary principles of biology is essential to our school education, and this knowledge alone will eradicate the tangled mass of ignorance, the cause of prejudice and superstition which obstructs the realization of practically every measure of social and economic progress in our country. The public in modern times must be made acquainted with the main implications of biological science and the possibility of its application in various spheres of corporate activity. I do not, for a moment, suggest that India has a monopoly of ignorance, prejudice, and superstition, but I do say that, owing to certain unfortunate historic forces as well as agelong traditions, some of the most important measures of public reform meet, in India, with an opposition of a kind rarely to be found elsewhere. Hence, it is easy to perceive that a live knowledge of biology is a desideratum in India, and is indispensable to success in social, political, administrative, and industrial leadership.

Take again the scheme of rural uplift, which has been recently sketched by Sir Frederick Sykes, recently the Governor of Bombay, at several durbars, and which must necessarily require the attention of biologists. Its success will obviously depend upon two main factors: the well-being of the body, and the well-being of the mind. The former involves production and availability of more food and prevention of diseases among the rural population, and we must remember that innutrition is our main physical disease. The well-being of the mind involves compulsory universal education, humanistic and scientific, to fight the forces of ignorance and superstition, and, here again, we must not forget that orthodoxy is our main mental malady.

One more illustration. As a consequence of the recent report on Bombay marine fisheries, an ambitious scheme for developing the fishing industry on a commercial basis has been put forward but I must point out that in the report itself there is no adequate recognition of the scientific research required for the problem. The scheme cannot be expected to yield any material results if the aid that is necessary from the pure zoologist is not forthcoming. Administrative schemes requiring scientific technique may often fail unless the administrator is wise enough to recognize that what passes to-day as seemingly useless knowledge may be indispensable to-morrow to the success of his project and makes a provision for it at the beginning.

Let me urge again that elementary biology should be introduced in our primary and secondary schools, as an independent topic of study along with the sciences of matter. The disciplinary value of the subject need not be dilated upon, as biology demands observation and manipulation, thought and deduction, no less than physics and chemistry. The advantages of a background of knowledge in biology even from the point of view of other subjects of school study are many and need no special pleading. A diffusion of biological knowledge can alone create a public opinion alive to the social questions of the day and willing to lend support to national schemes of reconstruction based on biological technique. Furthermore, if the man in the street understood a little about the mechanism of inheritance in man, if he know that the processes of life are ever changing and never constant, and that inheritance of physical as well as mental characters is dependent on necessarily varying factors of the parental germ cells, the containers of chromosomes and genes, then an unthinking or aggressive policy of social equalitarianism will have little prospect of success in India,—a consolation to our prosperous classes.

The modern tendency of introducing eugenic legislation in some of the advanced countries of the world must in due course be backed by public opinion. It is to be observed that the broad findings of eugenics as a science must be made known to the public by propagandist literature before such support is to be expected. I do not refer to the many controversial problems of this embryonic science, which has to wait, for their adequate solution, further investigations by the statistical or genetical methods. And therefore, it is imperative that legislative measures introducing birth control clinics, etc. should be given effect to with extreme caution and perspicuity. If, however, the physical as well as the mental characters of a person are irremediably determined by laws of heredity, so that upbringing and education, nurture and environment are matters of comparative unimportance, as has been so ably suggested in Dr. Lange's recent book based on a study of monozygotic and dizygotic twins, then, surely, eugenic legislation is the coming order of the day. Another material point to be borne in mind in this connection is that, apart from the question of eugenic legislation, a good deal of spade work can be done by giving wide publicity to eugenic facts and figures relating to hereditary abnormalities as well as differential birth-rates in different social classes. Many of the dysgenic habits of the populace and the resulting anti-social institutions can be eliminated by forming voluntary associations for specific purposes, and by founding institutions like the Institute of Criminal Biology which has been inaugurated in Bavaria for studying the criminal and the moral delinquents. It marks the adoption of a measure by a State which might well lead to a new doctrine of crime and punishment.

After taking into consideration the above facts of usefulness of the biological knowledge, it is still more surprising and at the same time humiliating to us to find that such an important science as Biology is occupying a lower place in relation to other sciences in educational institutions and also in public estimation. Vast sums of money are donated by people to be spent on physical sciences in a country which mainly depends on agriculture and hygiene—both biological subjects—for its material well-being. The causes of this inferior position of Biology are not difficult to find. Among others may be mentioned the well entrenched position of the physical sciences in the imagination of the public and hence in the educational systems.

It goes without saying that the physical sciences have given us the broad characteristics of our modern civilization. Industrialism sprang up as an offshoot of their sciences, and often we have applied their discoveries to serve our utilitarian purposes with or without forethought. Whether this industrialism has been an unmixed good is a question upon which I do not desire to pronounce any opinion. Lately, physics and applied mathematics have again come up to the forefront of our scientific enquiries, and one can scarcely converse in polite society without a passing reference to the theory of relativity or quantum physics. In the popular mind, physics had thus received a dignified position and a renewed prestige. Physicists have not refrained from taking full advantage of the situation. They commemorate with acclamation the anniversaries of their great scientists and their greater discoveries. We biologists on the other hand have not taken to such popular propaganda. Is it not in the fitness of things that we should have also our celebrations to remind us of our great pioneers : our Vesalius and Harvey, our Linnaeus and Cuvier, our Lamarck and Claude Bernard, our Wallace and Darwin, Weismann and Galton, Mendel and Bateson, Pasteur and Koch ? These are time-honoured names. They may not have captured the popular imagination, but the social services they have founded or made possible, often silently and unobstrusively, will surely be gratefully remembered by posterity.

This wide-spread propaganda by physicists and chemists has caused an unequal concentration of interest in physics and chemistry alone, which is ultimately reflected in our educational and administrative systems. An intelligent appreciation of the fundamental facts of biology is not therefore regarded as a necessary part of an equipment of an educated man. Even an eminent physicist or a chemist may be entirely ignorant of a biological knowledge to a degree quite impossible to a biologist in relation to physics and chemistry.

Biology has also suffered in the past more by a faculty presentation of its subject matter to its students and followers. Zoology had then meant nothing more than a mere dissection of dead bodies of animals and making by heart mere names of several systems and dry bones without trying to understand the relation between form and function. In short, the study of Zoology had created in those days an atmosphere of a slaughter house and had thus damped enthusiasm of the students. Botany had also shared the same fate.

But fortunately for us biologists, Biology has lately given rise to a distinctive method of scientific study. All attempts at interpretation of life phenomena on mechanistic principles for the avowed purpose of establishing the unity of sciences have not been yet successful. Life in living organisms must be accepted as a fact, and must remain, for the present, indefinable. The maintenance and co-ordination of function and organ, of environment, response, and adaptation, of the life processes of building up and breaking down, cannot be adequately explained by mere physico-chemical laws, but the glaring fact remains that living organisms, wherever they are found, tend to maintain and reproduce their kind through a co-ordinated development of their structure, activity, and relations with their environment.

Instead of making united efforts for encouragement of general biology, attempts are being made in some quarters to split up pure Zoology and Botany into a series of small sections, each section being devoted to a special economic end. We are required to teach that section of Zoology useful only for medical students, another section useful only to agriculture, and so on. 'In this sectional teaching a student is merely acquiring in Zoology or Botany a travesty of a noble subject (1).' Besides this, it constitutes a real danger in that these sections are forming enclosures within a science, while the research is more and more breaking down the walls between the sciences and thus making it possible to press the resources of other sciences into the service of Biology.

Effects of these and other causes not mentioned here, have accumulated to such an extent that biology is hardly thought of as a science. The result is that there is a one-sided development of sciences and ultimately of civilization.

In order to check this lop-sided development there is no better place than a school both primary and secondary where a bulk of populace gets their education, only a few of them being fortunate enough to enter the University for advanced knowledge. Study of elementary facts of all the sciences should be made compulsory in schools before specialization in any particular science is contemplated.

In primary schools where education is imparted through a medium of one of the Indian languages, suitable text-books dealing with biological facts and principles written in various Indian spoken languages should be made available to teachers and students. Likewise in secondary schools in which English is the medium of instruction, similar books written in a popular and easy style should be made accessible to the people concerned.

In the lower standards of both kinds of schools, a proper Nature study should be introduced. Boys and girls in these classes are eager to learn by curiosity and observation and they are thus able to follow the course of the Nature study if it is properly arranged. But the study as it is taught at present, unfortunately suffers from certain defects. In this study, plant biology is given an undue preference over the animal. I do not know whether it is due to any idea of indecency, prudery or difficulty of understanding ; since the animal biology will certainly involve teaching of sexual and reproductive organs of animal and their functions. In plants there are similar phenomena but the teacher does not seem to blush while describing them. The Nature study, if well balanced in subjects and truthful to nature, will satisfy the curiosity of these pupils and will also enable them to make comparative studies on their own observations.

In the higher classes of these schools, pupils should be taught and explained fundamental facts of biology, such as, Organic Evolution, Variations, Struggle for existence, and Inheritance and its modes. After these facts are grasped, the students should be explained the communal life of animals such as ants and bees with reference to specialized members of such communities and finally an outline study of the human society should be introduced to them.

During the course of the above study, the fact that man is an animal, should be made clear to these students who should be taught to compare all his actions, habits, behaviour, instinct, etc. with those of other animals lower in scale.

If biological study, based on some such principle very briefly described above, be made one of the compulsory subjects in schools, I am sure then that the future of Biology is assured and that the knowledge of its principles and facts will be diffused among the masses. The courses in colleges—Arts and Science—will also be improved in order to keep continuity with the school biology.

Now that constitution making has overshadowed all other political activities, it will not be out of place if I offer a few general remarks. Democracy with all that it entails in the matter of governmental machinery is an accepted fact, but in formulating legislation according to the wishes of the people, the legislators must seek help and guidance from trained scientific experts through the instrumentality of Standing Committees and Boards, which must receive constitutional recognition. The experts serving on such committees will be mainly drawn from the scientists of the country, and the science that will contribute, as much as any other, towards a true understanding of the complexities of modern state-craft, is biology and the sub-sciences of biology.

Finally, in moments of enthusiasm for my own subject I may have appeared to be unnecessarily captious in my criticisms but allow me to conclude with the hope that a study of biology may bring us a dim yet profound understanding of the mysterious significance of life that needs must fight the hostile forces of outward circumstance, and finally may illumine us from within with love of all life and sentiency.

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Section of Zoology.

Abstracts.

1. Studies on the ciliate, *Conchopthirus lamellidens* Ghosh, from the gills of a fresh-water mussel.

H. N. Ray *and* M. Chakravarty, Calcutta.

The morphology of this ciliate is described in detail. Presence of morphonemes have been demonstrated by various methods of staining. Structure comparable to neuromotor apparatus of *C. mytili* DeMorgan, described by Kidder, is not found to occur in this ciliate. Its method of feeding on gill-cells and sperms of the host has also been described in detail. Nuclear organization prior to binary fission and conjugation has been studied. The method of conjugation is different from what has been described in the case of *C. mytili* by Kidder in 1932. The chromatin contents of the nucleus, as shown by Feulgens reaction at various stages of its life-history, have also been studied in some detail.

2. A new species of the genus *Helicometra* from the intestine of *Trigla gurnardus.*

G. S. Thapar *and* J. Dayal, Lucknow.

The material for the present paper was collected by one of us from the intestine of *Trigla gurnardus* that died in the aquarium of the Zoological Society of London.

Various species of the genus *Helicometra* had been described, but Nicoll (1915) after careful consideration came to the conclusion that there is but one species of the genus—*H. pulchella*, all others being synonymous with it. The writers fully agree with this view.

The present species is interesting as it presents many differences from the type species, particularly in the shape and position of the cirrus and cirrus sac; the relative length of the pharynx and the œsophagus; the position of the testes and the genital pore; and the distribution of the yolk glands. All these differences, along with a few other minor points dealt with in the paper, indicate that the species is new to science.

The name *Helicometra gurnardus* n.sp. is proposed for this new form.

3. On a new trematode parasitic in the intestine of *Hardella thurgi.*

B. B. Sinha, Lucknow.

(*Communicated by Dr. G. S. Thapar.*)

A large number of worms were obtained from the small intestine of *Hardella thurgi* at Lucknow. These worms, on examination, appear to belong to the family Pronocephalidæ, and are interesting because they exhibit characters that connect the two subfamilies, Pronocephalinæ and Caraxicephalinæ, and justify their fusion under one name. A good deal of work has been done on this family, the earliest being that of Looss (1899). Since then much valuable work has been done, particularly by Price (1930).

The present new form is characterized by having boat-shaped body, concave ventrally; a simple collar; two posterior conical projections;

glandular papillæ covering the ventral surface in longitudinal rows; and two longitudinal rows of testes, preovarial and postovarial in position. A detailed account of the anatomy of the genus is given and is followed by a discussion on the position of the new form.

4. On a new trematode genus of the family Spirorchidæ from the vascular system of *Hardella thurgi.*

B. B. Sinha, Lucknow.

(*Communicated by Dr. G. S. Thapar.*)

The worms were collected from the larger blood vessels of the tortoise, *Hardella thurgi*, at Lucknow, and belong to the family Spirorchidæ. They resemble in general features the genus *Spirorchis*, from which they can be readily distinguished by the presence of a ventral sucker and the intestinal loop at its origin at the anterior end. In the presence of the ventral sucker, they resemble the genus *Vasotrema*, but differ from it in the presence of the intestinal loop, preovarial position of the testes and the postovarial position of the genital pore. The only other known genus of the subfamily Spirorchinæ is *Unicæcum*, from which it can be separated by the presence of both cæca, the presence of the ventral sucker, postovarial genital pore and the anterior intestinal loop. The present genus, therefore, appears to connect the already known genera of the subfamily Spirorchinæ, and can be readily distinguished from them in the characters enumerated above.

A detailed account of the anatomy of the worm is also given.

5. The bladderworm parasites of cattle in Lahore.

D. A. Kumar *and* Sukh Dyal, Lahore.

During the course of collection the authors have noted five types of bladderworms, of which *Echinococcus* is the most common. It has been found in the liver, spleen, kidney, lungs and mesentery, liver being attacked most commonly. One bladder had attained the size of a football. Another type of bladderworm is solid and hard, and is a conglomeration of small bladders. It is, however, rare and was discovered from the liver. Another common type is the *Polycercus*, bladders being found floating freely in the thoracic and abdominal cavities. A subtype of this is found lodged in the mesenteries. The last is the *Cœnurus* type which has so far been described from the brain and subcutaneous tissue of sheep, goat, and rabbit. The authors have found it in the mesenteries of a cow. Seasonal variations and the effect of parasites on the hosts have also been observed.

6. Observations on the tapeworms *Avitellina lahorea* and *Helictometra* from Lahore.

D. A. Kumar *and* Sukh Dyal, Lahore.

Avitellina lahorea was described from Lahore by Woodland who gives sheep or goat as its probable host. The authors have found it as a common parasite in cows. The largest specimen in the collection is 18 feet in length. In addition to the description of the head and other systems of the parasite the eggs of this species have been figured and described.

Genus *Helictometra* has so far been described from the cattle of Europe, Africa, and America. The authors found two specimens of this genus in the intestines of cows. *Helictometra giardi* is the nearest species to the present form. In *H. giardi* (Moniez) the uterus is undulating. In the Lahore form the uterus is straight, but develops pouches on each side at maturity. A detailed account of the worm has been given.

7. On the nematode causing stomach tumours of the Indian crocodile, *Crocodilus palustris*.

G. D. Bhalerao, Muktesar-Kumaun.

The worms causing tumours of the stomach wall of a crocodile shot at Jullundur have been identified as *Multicæcum agile* Wedl. This is the first record of these worms from a locality outside Egypt.

The worms present many interesting morphological features particularly in respect of the alimentary canal: the intestine having an anteriorly directed cæcum and the œsophagus possessing a small ventriculus from which arise two anterior and three posterior appendices.

The description of the species, which was incomplete in some respects, has been thoroughly revised.

8. Some observations on the common earthworm of Poona.

T. G. Yeolekar *and* H. S. Rai, Poona.

Pheretima posthuma has not so far been found and recorded from Poona. The earthworm which is commonly found is *Pheretima elongata.* The authors have noted variations in the number of spermathecæ and in the accessory glands of this worm.

It is interesting to note that the earthworm found on the north-east bank of the Mulla river and Deccan College side belongs to the Genus *Eudichogaster*.

9. A note on the polypoid (Cephalonion) galls of *Pongamia glabra* Vent.

M. S. Mani, Calcutta.

The polypoid (cephalonion) galls on the leaflets of *Pongamia glabra* Vent. have been wrongly described by previous workers to be formed by the mite, *Eriophyes cheriani* Mass. In this note the author has adduced experimental evidence to show that though found in the gall, the mite is not primarily responsible for its formation. The gall is originally formed by a minute undescribed Itonidid (Cecidomyid) fly and only certain minor changes in the gall are produced by the mite.

10. An annotated list of the Ichneumon wasps noted from South India.

T. V. Ramakrishna Ayyar *and* K. Brahmachari, Coimbatore.

Considerable amount of interest is now being evinced by economic zoologists in what is called the Biological method of pest control which consists in utilizing a parasite or a predator to control the pest. Among friendly animals which help man in this control work parasitic wasps play a very prominent rôle. And in order to enable workers to properly utilize these creatures a good deal of preliminary work in the way of systematic and ecological studies have to be carried out. This paper is intended to be a continuation of the work of the senior author on the bionomics and systematics on Indian parasites; papers have been published by him before on the Braconidæ, Chalcidæ, and on the known economic parasites. In this paper an attempt is made at making an up-to-date reference list of the Ichneumon wasps known from S. India with whatever the writers have been able to add in the shape of observations during their recent studies of this interesting group. This is the first list of the kind on this group for S. India and it is hoped it may help to some extent those embarking on the study of these insects. It may be added that apart from the economic importance of the group, there is the purely biological and scientific interest of such a faunistic and ecological study on one of the most highly organized group of insects—the Ichneumon wasps.

11. On the bionomics of a bag-worm on banana (*Acanthopsyche* sp.).

K. Brahmachari, Coimbatore.

The name bag-worm is generally applied to the caterpillars of the family Psychidæ, because of the characteristic habit of these caterpillars carrying bags with them. There is pronounced sexual dimorphism among them in that the males are normal while the females are degenerate vermiform creatures. The group has not attracted the attention of the Entomologists in India since it rarely occurs as a regular pest of cultivated crops. Though there are references to Psychids causing damage to tea plants, no detailed life-history of any species has been recorded so far. This paper deals with one of these which was found causing appreciable damage to banana in Madras.

12. First record of the Chalcid genus *Comperiella* H. from India (*C. indica*, n. sp.).

T. V. Ramakrishna Ayyar, Coimbatore.

In 1906 the genus *Comperiella* was erected by L. O. Howard to include an extremely interesting Chalcid wasp collected by the famous parasite hunter George Compere from China and the type was named *C. bifasciata.* Since then three more species of this genus have been described, one from Australia *C. pia* by Girault in 1915, the second *C. ceraptocera* by Mercet from Spain in 1921 and the third *C. unifasciata* by Ishi from Japan in 1925. The genus has not been recorded from India till now. A couple of years ago, while the author was engaged in the bionomic and systematic studies on South Indian scale insects and their parasites, one of the many novelties he came across was a wasp bred from a diaspine scale insect which on examination was provisionally regarded as a *Comperiella.* Due to want of time and sufficient material further examination of the insect was left in abeyance though a record of it was made in the author's bulletin on Coccidæ in 1930. Recently the study was taken up on further material becoming available and on comparison with the description of the three previously recorded forms it was found to be a distinctly new species. Being new to India and belonging to a beneficial group of insects the writer has described the insect in this paper under the name *Comperiella indica,* n. sp.

13. On the development of the peritrophic membrane in *Aedes* (*Stegomyia*) *albopictus* Skuse (Diptera).

P. Sen, Calcutta.

Divergent views are held as to the origin of the peritrophic membrane in insects. The author has previously shown in another group of dipterous insects, the Cecidomyiidæ, that this membrane is formed by the secretion of the mesenteric epithelial cells. Its formation in the *Aedes* mosquitoes has now been worked out and it has been noted that in origin the membrane differs very little from that of the Cecidomyiid, *Simulium, Psychoda,* and *Drosophila* as recorded by some previous workers.

14. The development of the female efferent ducts in *Apis* and *Melipona*.

C. J. GEORGE, Bombay.

During the larval stages the ovaries are situated on the 6th segment and the oviducts extend as thin strandular chords till they reach the 7th segment where they terminate in enlarged knobs and rest on the hypodermis.

During the early pre-pupal stage two median invaginations arise on the ventral side, one behind the 7th abdominal segment and the other behind the 9th. The anterior one extends forward, and, as it approaches the oviducts, bifurcates into two. The two resulting ducts meet the oviducts of their respective sides and ultimately fuse with them, thus establishing an opening to the outside. The vaginal opening at this stage lies behind the abdominal segment VII. The invagination behind the 9th abdominal segment develops into the acid and alkaline glands of the sting.

The vaginal opening which in the prepupa opens on the 7th gets later on shifted to the 8th. This takes place either by a definite invagination from the 8th segment (the spermatheca) which meets the vagina anteriorly or by the development of a groove extending from the vagina backwards and the gradual closing of this groove to form a tube or by the combination of these two processes. The vagina as a result of these changes comes to lie behind segment VIII. This process consists of (1) the development of an extension tube from the 7th to the 8th, (2) the development of a spermatheca.

This study further supports the author's findings given elsewhere that the primitive median vaginal opening was situated on the 7th segment.

Nel places the primitive spermatheca on segment VIII and criticizes Singh-Pruthi for locating it on segment IX. From the author's observations he postulates that primitive insects had spermathecæ on segments VIII and IX and possibly on VII also. In some that on the 8th was retained, the 9th one having lost its spermathecal function and retained only the glandular function. In other more evolved insects the 8th one was absorbed into the development of the vagina posteriorly and that on the 9th was retained. Blatella is an example where spermatheca is present on the 7th segment (Nel).

15. The metamorphosis of the ventral nerve chord in *Apis* and *Melipona*.

C. J. GEORGE, Bombay.

On the ventral nerve chord of the larva there are 3 thoracic and 8 abdominal ganglia. According to Nelson there are 3 thoracic and 11 abdominal ganglia in the embryo. He states that the abdominal ganglia numbers 8, 9, 10, and 11 fuse into a composite one later. Thus, excepting the last, all the ganglia are single ones.

During the pupal stage soon after defæcation the 1st abdominal ganglion moves forward and fuses with the metathoracic one. During a later stage when the legs and mouth-parts are about to unfold themselves, the 2nd abdominal ganglion moves forward and fuses with the preceding one. At this stage the penultimate ganglion, i.e. ganglion 7 moves forward and fuses with the 6th and comes to lie in the 6th segment. During the pupal stage, the compound ganglion of the metathorax fuses with the ganglion of the mesothorax and the composite ganglion comes to lie in that segment. Thus the adult ventral nerve chord is derived. The process described as 'moving forward' takes place by the shortening of the double nerve chord.

Snodgrass' account given on page 293 of his book 'Anatomy and Physiology of the Honey Bee' agrees with the foregoing. But he fails to reconcile the adult anatomy with the changes taking place during metamorphosis. According to him the penultimate ganglion of the adult bee lies in the 6th segment of the abdomen and innervates that segment. Specimens of *Apis dorsata* were dissected to see if the above statement was correct. It was found that the 6th abdominal ganglion gave rise to two pairs of nerves, as might be expected from its composite nature, of which the anterior pair innervated the 6th segment and the posterior pair the 7th segment. Snodgrass' description on page 237 is therefore obviously incorrect.

16. On the reproductive system of Bruchid beetles.

D. D. MUKERJI *and* M. A. HAKIM BHUYA, Calcutta.

In continuation of the work on the Bruchid beetles read before the Agricultural Section, Twentieth Science Congress, the authors have investigated in detail the anatomy and the histology of the reproductive systems of the two species common in the locality, viz. *Bruchus* (*Pachymerus*) *chinensis* and *B. quadrimaculatus*. While there are not many differences in the number and disposition of testes in the above two species, the shape and armature of the ejaculatory duct in each species are distinct. In the female reproductive system the number of ovarioles and the shape of the bursa copulatrix are different in the two species. The bursa copulatrix is large in these beetles and is provided with a pair of inside valves which prevent the passage of the penis within the upper lumen of bursa copulatrix. The spermatheca opens into the vagina anterior to the opening of the oviduct and receives the duct of the accessory gland which is long and slender. Attempt has also been made to study the function of the bursa copulatrix, by killing and taking serial section of the reproductive organ while the insects were engaged in copulation, as well as before and after egg-laying.

17. Preventing damage by termites in buildings in India.

S. K. GHOSE, Arrah.

In this paper the author reviews the behaviour and systematy of termites in India in general, with special reference to the species met with in Bihar and Orissa, and suggests measures found successful in minimizing risks of attack and also specific methods for making termite-proof buildings in which cement, non-corroding metal barriers, paradichlorobenzene, and other chemicals are effectively used.

Specimens of 'white ants', their queens and nests, as also specimens of attacked timbers will be exhibited in the meeting.

18. Diapause in the Mealy-bug *Monophlebus*.

MOHAN SINGH.

The phenomenon of diapause in insects has not hitherto been investigated in India. Mealy-bugs (*Monophlebus*) offer suitable material for this study.

The paper contains results of experiments for determining the effects of temperature, moisture, evaporation, and light on diapause.

19. Probable functions of the various parts of the nervous system of the Ak grasshopper (*Pœcilocerus pictus*).

SHAM SINGH.

This study was made by damaging different parts of the nervous system with an aseptic needle, and observing the effects of the operation on the general behaviour and activity of the insect.

The supraœsophageal ganglion seems to be the central organ of sensation. The subœsophageal ganglion has no co-ordinating function but is chiefly concerned with the control of the movements of the mouthparts. Each ganglion of the ventral nerve-chord is an independent reflex centre, and controls respiratory movements in its own segment.

20. Preliminary observations on the ecology of the house-fly *Musca domestica.*

NASEER-UD-DIN.

In this paper are given the results of experiments concerning the effects of temperature and humidity on the eggs, larvæ, and pupæ of the house-fly *Musca domestica.*

It has been found that 35°C. is the optimum for pupal formation, as at this temperature all the larvæ underwent pupation. 6°C. and 45°C. are the minimum and maximum temperatures for the larvæ. No emergence of flies takes place at 40°C. or above.

70% humidity seems to be the optimum for pupation and emergence of flies.

21. Observations on some factors governing the emergence of Anopheline mosquitoes.

P. SEN, Calcutta.

The actual processes involved in the emergence of adult mosquitoes from the pupal stage have been detailed in this paper. The hours of the day favoured for emergence by the various species of Anophelines together with some instances of daily fluctuations in the hours are given. The time required for this act varied considerably in the different species; altogether ten species have been considered. The effect of light and temperature on the emergence of mosquitoes are also dealt with. The study proved that a spontaneous control is maintained over the species during this transforming period through structural deficiency and malformations of locomotory organs, or through the activities of different parasites and predatory bodies.

22. A note on the occurrence of a style-sac in some more Gastropod genera.

R. V. SESHAIYA, Annamalainagar.

Dr. Yonge has recently made a list of forty-one Gastropod genera in which the style-sac has been recorded till now. From this list *Ampullaria* will have to be deleted, since Bouvier's observation on the occurrence of a style-sac in its stomach has not been confirmed by Dr. Prashad's investigation.

The present note records the presence of a style-sac in two more Gastropod genera, viz. (1) the fresh-water *Septaria* (Neritidæ), and (2) the terrestrial *Cyclotopsis* (Pomatiidæ).

In both the genera the style-sac communicates by its entire length with the intestine; but in *Septaria* the communication is wide and open, while in *Cyclotopsis* it is restricted or narrow.

23. Preliminary observations on the life-history of *Gobius neilli* Day.

R. GOPALA AIYAR, Madras.

The paper deals with the early stages of development after fertilization.

After fertilization the outer cover of the egg swells out into a club-shaped structure. The micropyle comes to be placed at the narrow end of the club through which mucilaginous threads flow out and anchor the egg-case to the substratum. The case itself is packed with a jelly-like material in the centre of which the embryo undergoes its development.

Early stages of development are described. The embryo is almost fully formed 24 hours after fertilization. The head, eye vescicles, brain, and notochord are established.

The details of development during the second and third day after fertilization are also given. Hatching takes place just before the commencement of the third day. Methods of hatching and further details of the free swimming larva are described.

24. On the structure of the pyloric cæca in the Family Ophiocephalidæ.

M. Rahimullah, Hyderabad (Deccan).

Four species, viz. *Ophiocephalus marulius, O. striatus, O. punctatus,* and *O. gachua* have been investigated. Two cæca are given off just at the commencement of the small intestine.

The cæca in these fishes are two tubular outgrowths of the intestine and vary considerably in size in relation to the alimentary canal, and they also differ very much in form and arrangement in other teleostean fishes. As a rule, in the Ophiocephalidæ, the right cæcum is always smaller than the left.

The cæca are true outgrowths of the intestine as has been corroborated by their histological character. Each cæcum is more or less a finger-like structure, and may be tapering to a point as in *O. marulius* and *O. striatus,* or club-shaped in *O. punctatus,* or slightly pointed in *O. gachua,* and communicates with the intestine by means of an orifice not guarded by any sphincter muscles like those present at the posterior end of the pylorus. On average the *ratios of the length of the cæcum to the intestine* as well as to the *total length of the whole of the alimentary canal* in *O. marulius, O. striatus, O. punctatus,* and *O. gachua* are

$$\frac{1:6{\cdot}2}{1:5{\cdot}2} \text{ and } \frac{1:8{\cdot}7}{1:7{\cdot}3},\ \frac{1:3{\cdot}9}{1:3{\cdot}2} \text{ and } \frac{1:5{\cdot}2}{1:4{\cdot}2},\ \frac{1:6{\cdot}6}{1:4{\cdot}8} \text{ and } \frac{1:8{\cdot}6}{1:6{\cdot}2}, \text{ and } \frac{1:7{\cdot}1}{1:5{\cdot}7} \text{ and } \frac{1:8{\cdot}5}{1:6{\cdot}8}$$

respectively (in each case the numerator denoting the right cæcum and the denominator the left cæcum).

Their blood- and nerve-supplies have also been recorded.

The histological details of the whole of the gastro-intestinal tract have been carefully studied in each of these species.

These pyloric cæca may tentatively be regarded, in view of their morphological and histological characters, as accessory food-reservoirs, supplementing probably both digestive as well as absorptive functions. Bile and liquid food (deep brown in colour) have invariably been observed to fill their cavities.

25. On the bionomics, structure, and mode of intestinal respiration in certain loaches obtained from the Nizam's dominions.

B. K. Das, Hyderabad (Deccan).

Two types of loaches found in Southern India have been investigated, both being usually confined to the shallow corners of the rivers away from the main current, and are less frequently met with in ponds or tanks. Breeding takes place during the first showers of rains (May-June); the eggs are laid in the shallow part of the river where dirty water collects, and the larvæ hatch out in about three weeks' time. They are quite abundant during the winter, but only a few are seen during the summer, when, if the mud or sand dries up superficially, they bury themselves completely in the wet mud below and æstivate, lying in a torpid condition, until the rains set in and resuscitate them from their 'summer sleep'. They often prefer to lie buried in the sand or mud, usually with the head and the tail-fin (sometimes this also might disappear from sight completely) peeping out of the substratum. In this position they would remain from half an hour to 2 or 3 hours.

The fish adopts both the *branchial as well as intestinal modes of respiration*, the gill-breathing is extremely fast and goes on very vigorously, on average 238 oscillations per minute. In dirty water (containing very little O_2) branchial respiration is practically suspended, and in its place the intestine serves as an accessory organ of breathing, and under such circumstances it could survive for at least 72 hours. Under normal conditions in clean water, however, it occasionally (intervals varying from 2 to 5 minutes, or even less according to the temperature and the O_2- and the CO_2-contents of the water) darts off to the surface (often popping nearly $\frac{1}{4}$ or $\frac{1}{3}$ of the anterior part of its body), opens its mouth and takes a gulp of air very quickly, and immediately after it makes a complete somersault, and at the same time driving out the used up gas from its intestine through the anus (8–12 bubbles) with such an energetic force as to produce a distinct sound. A peculiar kind of clink is also invariably heard when the fish is taken out of water and handled on the ground due to the same cause.

Intestinal respiration is known to occur among loaches, the best known example being *Misgurnus fossilis*. Dobson described this phenomenon in the case of the Indian loach, *Lepidocephalichthys balgara*. The author has described the results of experiments on the asphyxiation of the above-mentioned species. The behaviour of these fishes to perfectly dry conditions is also indicated. The internal structure, nerve- and blood-supply of the alimentary canal are also discussed.

26. A statistical study of growth in *Therapon jarbua* Day.

S. Ranga Rao, Madras.

It is found that the first yearlings live in the brackish waters of the Adyar and Cooum rivers and the second in the open sea.

Observations on the condition of the gonad and the spawning season seem to indicate that the first yearlings pass into the sea to attain sexual maturity.

A representative collection of specimens was made from October '32 to September '33. The rate of growth for each month is deduced from frequency graphs. The lengths for age in months are also tabulated.

There is reason to think that the rate of growth of the second yearlings is greater than that of the first, probably due to the change from brackish water to open sea conditions.

It is noted that the rate of growth is above average during the cold months December and January, average from January to March and below average during summer, i.e. from April to July. It is suggested that the quantity of food available in various months must be responsible for the fluctuations in growth.

27. The phasical morphology of the thymus gland in some common European fishes and in two Cyclostomes.

S. H. LELE, Bombay.

This paper is a continuation of the author's paper 'On the phasical history of the thymus gland in plaice of various ages', etc., published in the *Journal of the University of Bombay*, Vol. 1, pt. V. It has been thought so far that the thymus gland disappeared or became reduced to a vestige in fishes at or about the time of their maturity. This investigation has shown that this is true only in the case of some fishes like Dogfish, Herring, and Trout. In the case of flat-fishes and rays, on the contrary, the thymus is found to grow even after their reaching maturity.

28. On the variations in the arterial system of the common Indian bull-frog, *Rana tigrina*.

N. K. SINGH, Agra.

In *Rana tigrina* there are considerable individual variations in the arteries. Mostly these variations are graded. They cannot be interpreted as abnormalities and they have not so far been mentioned.

The author has indicated the various ways in which the cardiac, the musculo-glandularis, the œsophageal arteries arise. The relationship of the subclavian artery of each side with the branchial nerve is given. It is shown that the urinogenital arteries vary in number and supply, the posterior lumber arteries are very variable in their origin, the posterior mesenteric artery varies considerably from its normal position and besides these individual variations several other abnormalities were observed by the author and are described in detail.

29. A contribution to the study of the plankton in the Bombay harbour.

S. H. LELE *and* (MISS) P. B. GAE, Bombay.

The present paper is based on the samples of the surface plankton of the Bombay harbour collected at least once a week during the year 1932-33. This work has shown that there are cyclic changes in the quantities of daily catches made under constant conditions and the influence of the various physical factors connected with these changes is discussed in this paper.

A superficial examination of these planktonic catches has shown that the macro-organisms in these catches fall into three chief categories. The first consists of animals like *Sagitta* spp. which are found throughout the year in varying quantities. The second consists of organisms as fish eggs and fish and crustacean larvæ which lead planktonic life and appear for short periods. The crustacean larvæ, when present, form the major part of the catch. To the third category belong organisms like sipho-, hydro-, and scypho-medusæ, diatoms, and dinoflagellates which are planktonic throughout their lives but which appear in the Bombay creek for short times at intervals. When present they appear in swarms, thereby increasing the quantity of the catch and appearing to monopolize the whole of the habitat.

Further work is being carried on.

30. The mechanism of the posterior limb of the climbing Marsupials.

B. M. LAL, Hyderabad (Deccan).

In this paper, the author has endeavoured to show that there is more extensive movement in the posterior limb of the Marsupials that lead wholly or partly an arboreal life, than in the posterior limb of the terrestrial Marsupials or in Eutheria. The posterior limb of the climbing Marsupials resembles the anterior limb in many respects. The joints between the two bones of the leg permit a limited amount of pronation and supination. These movements are effected by the tibio-fibular interosseous muscle and by Pronator Tibiæ or M. Popliteus, which in these animals functions as a pronator muscle on account of its origin from the fibula. The influence of habit on the posterior limb of the climbing Marsupials is discussed. The muscles of the posterior limb of the entirely arboreal and slow moving *Didelphys* are comparatively much weaker, and its bones comparatively much longer and more slender than those of the partly arboreal and partly cursorial *Dasyurus Viverrinus* or those of the partly saltatorial and partly arboreal *Dendrolagus*. It is also pointed out that structurally the foot of *Didelphys* is most primitive, and resembles the hand of quadrumana or man.

31. On the development of the vertebral-centra of the vertebrates.

H. K. Mookerjee, Calcutta.

Contrary to the opinion of the previous authors, the writer holds the view that the different vertebrates follow a general basic principle in the formation of the vertebral-centra. After the formation of the notochord and its sheaths, the skeleto genous layer aggregates round them forming an outer jacket known as the perichordal tube. In the vertebral region, in some cases, the perichordal tube is very thin, in consequence of which, perhaps, the previous workers thought that the arcualia (dorsal or ventral arches) directly sit on the notochordal sheaths. The perichordal tube then becomes osseous in the vertebral zones. Intervertebral portions of the perichordal tube remain membraneous or procartilaginous for a long time. Through these intervertebral zones of the perichordal tube the migratory connective tissue cells pass in. In a procœlous vertebra as in Anura, in some Lacertilia, Ophidia and in some Chelonia, the direction of the migratory connective tissue cells is cranio-caudal, while in the case of a ophisthocœlous vertebra as in higher Urodela, some Anura, and some Chelonia, the direction is reverse of what has been stated. These migratory connective tissue cells cut the intervertebral zones of the perichordal tube into two portions, and the synovial cavity is formed between these portions. The formation of the intervertebral synovial cavity starts from the periphery and not from the centre of the intervertebral element as described by the previous authors. The anterior portion of the intervertebral zone of the perichordal tube goes to form the posterior part of the preceding vertebral centrum by fusion, and the posterior half of the intervertebral zone constitutes the anterior part of the next vertebral centrum. In the case of amphicœlous vertebra, the migratory connective tissue cells instead of getting in through the membraneous intervertebral zones, aggregate round them so as to form three bands, one behind the other. The middle band is responsible, either, for the formation of the intervertebral ligament as in fishes, lower Urodela, some reptiles and in birds, or for the formation of the intervertebral disc as in mammals. The lateral bands ultimately become cartilaginous forming the two surfaces of the vertebral-centrum. So that neither the notochord nor its sheaths play any part in the formation of the intervertebral ligament, although that is the opinion of the previous workers.

✓ 32. Preliminary study of the embryology of *Wallago attu.*

Nazir Ahmad.

The ripe egg of *Wallago attu* possesses a germinal-disc before fertilization. The endoderm is sormed by the invagination of the margin of the blastoderm within five hours after fertilization. The segmentation-cavity lies between the two primary germ-layers. The mesoderm makes its appearance as two lateral bands, which are thickest at the Kupffer's vesicle and gradually become thinner towards the anterior end. The notochord also becomes manifest in the region of the Kupffer's vesicle, and arises from the endoderm. In *Wallago attu*, as in other Teleosts, the archenteric cavity is absent, the alimentary canal arising as a solid structure.

33. Cytoplasmic inclusions in the oogenesis of *Gobius neilli* Day.

M. K. Subramaniam *and* R. Gopala Aiyar, Madras.

The cytoplasmic inclusions were studied from fixed material as well as *intra vitam*.

The mitochondria occur as a dense cloud of granules immediately surrounding the nucleus. With the growth of the oocyte they were seen to move almost in the form of a ring away from the nucleus leaving a fairly clear space round the nucleus. They multiply quickly and soon occupy the whole area of the cytoplasm. They are not observed to take part in deutoplasmogenesis.

The Golgi apparatus occurs as an irregular mass just touching the nuclear membrane. This breaks up and moves into the surrounding cytoplasm in the form of granules. Later they seem to be associated with fatty yolk globules.

Fat and fatty yolk both occur in the egg. Fat seems to arise from nucleolar extrusions. Fatty yolk probably arises by condensation of material by the Golgi apparatus.

34. Cytoplasmic inclusions in the oogenesis of *Clibanarius olivaceus* Henderson.

M. K. Subramaniam, Madras.

A description of the cytoplasmic inclusions in *Clibanarius* leading to the formation of albuminous and fatty yolk grains is given. The mitochondria which occur in the youngest oocytes as a circumnuclear nebulous cloud resolve themselves into definite granules and form a concentration below the cell membrane at one pole of the egg. Masses of mitochondria clump together and these clumps, in association with Golgi batonettes, seem to give rise to albuminous yolk grains.

Fatty yolk is formed by the enlargement of Golgi elements into Golgi vacuoles with subsequent condensation of fatty yolk material in their interior.

A seasonal change was observed and it was found that when the river bar was open the eggs were small and contained large numbers of fatty yolk droplets. In summer when the bar was closed the oocytes were larger in size and contained more of albuminous yolk grains and less fatty yolk droplets than during the former period. The unmodified Golgi elements in this series of preparations were observed to clump together and give rise to albuminous yolk grains in association with Golgi batonettes.

The cytoplasmic substances synthesized by the nucleolus are sent out as extrusions and these seem to be condensed by the Golgi batonettes and utilized in the formation of both kinds of albuminous yolk grains.

Section of Botany.

President :—PROF. R. H. DASTUR, M.SC.

Presidential Address.

THE NATURE OF LIVING MATTER.

> ' *There was a door to which I found no key ;*
> *There was a veil past which I could not see.'*
>
> OMAR KHAYYAM.

I.

INTRODUCTORY.

I propose to depart from the traditional practice of my honourable predecessors in the chair, of taking stock, like a trader, of the existing knowledge in the subject of my special research, as I am afraid it would provide entertainment to only a few in your midst; and though fully cognizant of my own limitations, I am going to speak to-day on a mighty but enticing theme of the nature of living matter. I possess no other qualification to take up this subject except that I happen to be one of those who study the life processes of living organisms.

Problems of the origin and nature of life have attracted the attention of man from the earliest times; philosophers have sought to tackle them and latterly men of science have tried to unravel the Great Riddle. The interest in this topic transcends all other human interests and it is the aim of all thinking men to understand what life, in its ultimate analysis, is.

The subject of the Nature of Life has given rise to controversies and discussions unparalleled in human history. It has proved the *pièce-de-résistance* that separated the opposing schools of thought at different periods of history; and it has been found impossible to effect a conciliation between the ' materialists and the idealists ', the ' nominalists and the realists ', and ' mechanists and the vitalists '. I do not intend to review the contentions between the opposing sets of tendencies; but I believe a discussion of the nature of life does not lie beyond the province of the biologist as the biological science has made important contributions towards the solution of this problem.

In the pre-evolution times, the philosophers tried to fathom the meaning of this world riddle from all directions and by help of imagination formulated various important and original conceptions based on abstract thinking. These conceptions were not based on any experimental knowledge; they were more or less matters of faith and feeling. Many metaphysical concepts, supposed to underlie all reality, were enunciated. Spinoza's substance, the Monads of Leibnitz, the Duration of Bergson and God of Berkeley are some instances in point. Though all these products of the mind will live for ever in the memory of men, when examined closely and critically, they fail to explain the concrete character of the world of reality. So the mystery of life and the universe remains as unfathomable as ever.

With the advancement of scientific knowledge during the last century and after, the evolutionary doctrine, though older than Aristotle, has become firmly established. Herbert Spencer, though he could not explain the origin of life which he regarded as made up of subvital processes, explained the evolution of living organisms as governed by the universal law of the redistribution of matter and energy. Bergson, another great exponent of evolution, arrived at the principle of simple Duration which underlies, generates, and creates all reality. This creative Duration is the source of all the activities and multiplicity of forms in the concrete universe.

On two historic occasions the Nature of Life has been a topic of discussion at the meetings of the British Association for the Advancement of Science. In 1912, Prof. Schafer in his Presidential Address supported the mechanistic interpretations of life, putting forward the general principle that all changes in living things were governed by laws identical with those that governed inanimate Nature. In 1929, the nature of life was once more a subject of a memorable joint discussion in which celebrated men of science in Great Britain took part; the rival schools of thought put forward their view-points based on their researches in the different walks of science, on the nature of the eternal mysteries of life. Vitalism and mechanism were for long the two governing concepts regarding the nature of life and to this the third concept of Holism or whole-making has been recently added by General Smuts.

MECHANISM VERSUS VITALISM.

From the earliest times philosophers have discussed the characteristics of living organisms and have graded the universe into several distinct and separate groups called men, animals, plants, and minerals. With the advent of science, the whole universe came to be interpreted as a machine and all natural phenomena were resolved into mechanical models. Since the times of Newton, the physicists have tried to determine and to predict the behaviour of material particles by the application of mechanical principles. The definite characters of the continuity between the organic and the inorganic have now been established and the theory of evolution has bridged the gulf between men and animals.

The mechanistic view of life now held by biologists and other scientists had its roots in the mechanistic schemes of physicists, for the same principle was employed by them for elucidating the behaviour of living organisms. As a result of these conflicting attitudes, two schools of thought arose, one affirms that all the manifestations of life are physico-chemical in character while the other advocates that a mental or spiritual force acts in co-operation with the material forces known to science. The old controversy dating back from Democritus between free will and determinism has been revived in a new form and each side tries to fortify its schemes and theories with arguments that tend to support its own view-points. The mechanists argue that every event from the movement of the planets to the wind that blows, once attributed to supernatural agencies, could now be explained in terms of material agencies, and even unexplained events like the activities of organic beings can be reduced to law and uniformity ; and in fact all occurrences in nature will in reality come to be understood as the results of the operations of natural laws. (*Vide* Elliot.)

The vitalists on the other hand hold that as living bodies exhibit a mental and spiritual life of which no counterpart exists in inorganic bodies, the continuity established by science between the inorganic and the organic is merely material continuity. In the universe all events are brought about by two agencies, one the mechanical which works by an uniform procedure and the other the vital which works in a capricious and arbitrary manner and which, by its own nature, is incapable of reduction to any scientific laws. The vitalists advance three kinds of arguments: (1) argument of ethical character, (2) argument per exclusionem, and (3) argument of direct introspection. All these three are refuted. The vitalists argue that if the mechanistic theory is true, there is nothing like moral responsibility. But facts must be faced even though they may be repugnant to our moral sentiments. The logic of per exclusionem is wrong as events that cannot be explained at present on mechanistic principles will not remain inexplicable for all times. Thirdly, we know that we can raise our arm but we do not know how we raise it. (*Vide* Elliot.)

The term vital factor or vital activity is frequently used in plant physiology but it is used in quite a different sense to that in which it has been used before. The term 'vital' factor simply suggests that living cells participate in processes like the ascent of water or the conduction of stimuli in plants, the part played by them being inexplicable in terms of physics and chemistry. Many of the physiological processes which were at first inexplicable in physico-chemical terms are now explained in these terms as our knowledge of the process and also of the physical and chemical sciences have advanced. Physiologists no longer believe that the synthesis of complex substances in the plant body is due to the activity of a vital factor, in the sense in which it was understood formerly, though their synthesis in the plant body is still shrouded in mystery. So as knowledge grows it is likely that the term vitalism will, if it at all survives, come to indicate nothing more than the subtly complex types of mechanisms. (*Vide* Stiles.)

It is true that life, as it is, cannot be explained on the basis of organic chemistry and the physics of the colloids, for chemistry and the physics of living matter are very likely more intricate than those of the inorganic matter. Even though the difficulties in the way of the physico-chemical theory of life have not disappeared as it was expected forty years ago, there is no reason to despair and to fall back on the belief that some extra physical entity must of necessity be existing which alone can explain the phenomena of life.

Though the mechanistic view of life has been productive of new knowledge regarding the nature of living matter, it must be admitted that the difficulties of explaining the specific characters of vitality have been more and more realized. The growth of living matter which includes and is the outcome of the incorporation of the dissimilar or non-living matter is something *sui generis*. The false comparison of the growth of bioplasm with the growth of a crystal as made by various mechanists do not give them any credit as the two processes are quite different. Living things are again characterized by their capacity of producing antigens for the reproduction and differentiation of tissues and for the unceasing transformation of energy which is the expression of a reversal of the second law of thermodynamics. The physico-chemical explanation of vital processes present far more formidable difficulties now than it did at any time during the past, and, as our knowledge advances, the sphere of our ignorance is ever widening. So it may; but that should not drive us to abstract logic, or to invoke the aid of metaphysics. It is unfortunate that this has been done, and many biological philosophers and philosophical biologists like Bergson, Driesch, Uexkiell, J. Arthur Thomson and Woltereck have reverted to the vitalistic theory of life and have gone back to the old view that the phenomenon of life cannot be explained in terms of the working of a machine and that there is always an unseen regulating vital factor. The vitalism of Driesch, who is aptly called the father of experimental embryology, rests on the fact that no mechanical explanation can be found for the process of growth and regeneration, and for conscious action. Driesch gives the example of an egg, any portion of which would develop into a whole organism. If the mechanism of the development of the organism is in the egg, how can a portion of the egg develop into a whole organism, as a part of a divided mechanism cannot function as a machine? But this argument of Driesch is ably met by supposing, that, the special growth promoting substances for different parts not having been segregated, the potentiality of development persists in each of the divided portions of the egg. Secondly, it is suggested that the development of an egg into an organism signifies a purpose. When development is completed, it is seen that it has an object. It makes use of energy and matter in such a way as to promote that purpose without contradicting the laws of matter and energy. Driesch designates the controlling principle with the Aristotelian name of 'entelechy' and the controlling action as 'psychoid'. There is a dispute as to the exact meanings of the word 'Entelechy' as conceived by Aristotle and Leibnitz and as interpreted by Driesch and his followers. According to Leibnitz each monad is entelechy, i.e., it is the principle by which a whole is an individual, and it never exists distinct or apart from its parts. According to Driesch, entelechy is not energy; it is a guiding principle which directs the energy as known to science; there are not as many entelechies as there are organisms, the controlling principle is the same and the different results obtained with the eggs of different animals are due to the differences in the materials that are at the disposal of the common controlling factor. If the assistance of a metaphysical entity in explaining organic activity needs be taken, apart from the violation of the general principle of non-multiplication of entities, we are no longer within the domain of science; besides, the problem loses its intrinsic interest and value. Vitalism cannot be taken as a starting hypothesis as suggested by Doncaster as it stifles all inquiries on account of its non-material character.

HOLISM.

Smuts has recently given a third governing concept about the nature of life and has named it 'Holism' or the whole-making tendency. He affirms that he has tried to reach a concept of nature by reference to nature and to nature's own standards, thus absolving the concept from any anthropomorphic taint. I think it will be necessary to refer to the new concepts of matter before we discuss 'Holism'.

Recent advances in physical and mathematical sciences have not only revolutionized our concepts of space and time but they have also changed our concepts of matter. The concept of the fixity of atoms so long held by chemists has now become obsolete. The structure of atoms is now known to be made up of units of electrical energy revolving with immense velocities in the space-time medium. The whole of the material world is thus the result of an electrical structure and the differences in the chemical properties of atoms of the different elements are mainly due to differences in the structural arrangements or groupings of these units of electrical energy. The discovery of these facts leads us to important generalizations. Matter is not inert or passive, as it was always supposed to be, but it is active. It is creative,—though not of its own stuff—of new forms and patterns resulting in new properties. The discovery of radio-active elements has also shown that the genesis of one element occurs from another with the liberation of these units, or groups of units, of electrical energy.

Taking advantage of these recent advances in the different sciences, Smuts tries to show that matter and life are not distinct, separate entities, rather they overflow into one another to form the progressive series of the great process of whole-making. Thus there is a definite tendency of whole-making in the universe. Matter and life consist of unit structures like electrons and cells, whose ordered grouping produces natural wholes which are called bodies and organisms. An atom of hydrogen is made up of an electron and a proton, but as a whole the atom of hydrogen has different properties from those of the electron and the proton taken separately. The whole-making results in new emergent characters. Thus the whole is something more than the sum of its parts. Similarly a plant or an animal which is made up of its parts is more than the sum of its parts. This concept of whole-making is applied by Smuts to explain the nature of life. According to his concept, life is neither a force nor a substance. It is not an aggregate of chemical compounds. Life is merely a new emergent character or property arising from a more complex type of whole. Just as the properties of water are not in its parts hydrogen and oxygen so is not life in its parts; it arises from the synthesis of its parts and appears in new emergent qualities and behaviour. Life is a new feature or property of a complex whole, and cannot be discerned in its parts. Now this tendency of whole-making is seen at all stages of existence from the imperfect inorganic wholes to the perfect biological wholes and finds its highest expression in the mental plane of existence. Holism, as advocated by Smuts, is not a mere metaphysical concept; it has a definite character and it underlies all concrete reality. It is the very cause of evolution. [*Vide* Smuts (1927).]

The doctrine of holism and the doctrine of emergent evolution of Professor Lloyd Morgan have much in common. The emergence of new characters by each substantial change of plan in nature is called by Morgan emergent evolution. A new plan or grouping of complex natural atoms is raised, as if with a sudden jump, to a high emergent level, and possesses new properties. The difference between holism and emergent evolution lies in the stress laid upon the whole-making tendency as advocated by the former and the emergence of new properties from new groupings as suggested by the latter. According to holism the tendency of whole-making is the main principle while the emergence of new properties is only one of its features.

The doctrine of organic mechanism as laid down by Prof. Whitehead in ' Science and the Modern World ' is, ' though derived from different reasonings. strikingly similar to the doctrine of holism '.

All these doctrines have their basis in the discovery of the important fact that different groupings of electrons or cells result in new properties. In inorganic and organic nature, groupings have occurred in ascending order, but it is not correct to assign the rôle of fundamental activity or principle to them. The fact of the emergence of new characters with new combinations is perhaps as fundamental in explaining all reality in the universe as the tendency of whole-making. It savours of anthropomorphism which Smuts tries to avoid in giving us a true concept of nature. To attempt to attribute all reality to a single fundamental principle or activity is to enter the domain of philosophy. Nature seldom works by simple methods. Holism is akin to a finer form of vitalism though it is dressed in scientific garments trimmed and lined with the latest designs and aids of science. But to a man of science it carries no conviction; to an inquiring mind it brings no relief.

The emergence of new specific characters at different levels of groupings and combinations is recognized since the time of J. S. Mill and Lewis. It has given rise to the ' emergent ' or ' resultant ' hypotheses. And though at present these properties cannot be deduced from the study of its parts due to the imperfection of our knowledge, it is premature therefore to conclude that they are inexplicable as General Smuts asserts. It is now conceded that an electrified particle like the electron is not competent either to emit or absorb light so long as it is free. It can be pushed along by waves, but it cannot absorb them. To be a radiator or an absorber it must be associated with another electrified particle of the opposite sign, i.e., it must be a constituent of an atom. It thereby acquires new properties. But this does not mean that new properties have been generated or produced; there is merely a display of new properties which were perhaps latent. [*Vide* Lodge (1930).]

The great contemporary critic of the mechanistic theory of life is Professor J. S. Haldane who thinks that the concept of holism is essential for proper understanding of the physiological processes of living organisms and for the right interpretation of the relations between the organisms and their environment. Haldane appears to put a different interpretation to the term holism from that implied by the original inventor of the term; in fact, the fact of co-ordination in life is something radically different from holism. Prof. Haldane, in his Gifford lectures, has also pointedly denied the possibility of explaining by the mechanistic concepts the problem of conscious behaviour. He writes 'a time has now come for giving a decent burial to the mechanistic theory'. But let us see what he means by conscious behaviour.

According to the Cartesian doctrine, body and mind are two different parts of an organism and the methods of physics and chemistry that are applicable to the body are not applicable to the study of the mental processes. The physiologists deal with the former and psychologists with the latter. According to Haldane the traditional mechanistic methods of physiology have nothing to say about the distinctive characters of conscious behaviour, and that a behaviour ceases to be called conscious as soon as it is possible to bring it within the range of scientific prediction. Even if we are able to analyze conscious behaviour with reference to space-time framework by the physico-chemical methods, Dr. Haldane's position is unassailable, as conscious behaviour subjected to such an analysis ceases to be conscious. The work of Pavlov and his school on the study of conditioned reflexes have a great bearing on this important point and has emancipated the notion of the dualism of the body and the mind from biological studies. As Hogben says it has obliterated the distinction between reflex and voluntary behaviour and it has shown how conditioned reflexes can be brought into being. In view of Pavlov's work conscious behaviour is no longer outside the domain of traditional physiology and to analyze it, introspective speculation and concepts are not at all necessary. Modern physiology now successfully investigates these characteristics of living beings associated with the term consciousness and it is very likely that the physiologist will soon be able to explain these in terms of physics and chemistry. Time was when the problem of conscious behaviour used always to be discussed by philosophers and the reflex activities alone were investigated by physiologists. But nowadays the physiologist has spread his tentacles beyond the boundary line that separated physiology from psychology and moral philosophy in the past. (*Vide* Hogben.)

These recent conversions of men of science to vitalistic conceptions or their abandonment of the mechanistic views are mere expressions of despair. It is indicative of a depressed state of mind after a period of over-enthusiasm. The adoption of such a defeatist policy may deplorably affect the expansion of knowledge and perhaps act as a brake on the progress of science. To a layman it would appear as if science could go 'thus far and no further'. The best reply to him is given thus:—

> 'At first, this earth, a stage so gloomed with woe
> You all but sicken at the shifting scenes
> And yet be patient, our playwright may show
> In some fifth act what this wild drama means.'

AFTER HOLISM.

Though it is rash for a botanist to invade the territories of the physical sciences, it has become unavoidable to venture therein. For a discussion on the nature of living matter would remain incomplete without any reference to the revolutionary changes that have occurred in the physical and mathematical sciences. Strict adherence to the principle of causation which dominated the scientific thought of the nineteenth century has now been shaken by researches in experimental physics; and in its place reign the laws of indeterminacy and probability. The hope of Sir Isaac Newton, 'Would that the rest of the phenomena be deduced by like reasoning on mechanic principles', has no hope any more to be realized.

Experimental physics first resolved matter into its constituent particles carrying electrical energy. Wave mechanics reduced these electrical particles of matter to what are now called group waves. The quantum theory which broke down the law of causation effected a reverse change and showed that what we regarded as waves had in some respects the properties of particles. The electrons, protons, and photons, which are now a 'part of the A B C of physics', behave sometimes as waves and sometimes as particles obeying the laws of probabilities. The solidity of matter has thus been destroyed. Electrons or protons cannot be observed singly or separately, but when they come together a visible event occurs which affects our senses. The electrons have no existence in reality. The true 'objective reality' is in the events. [*Vide* Jeans (1933).]

Similarly it is believed by some mathematical physicists that space has no reality and is merely a mental concept. Thus the world of the physicists is a 'shadow world'. And they are now content to deal with abstract symbols like tensors and matrices which stand for things which are largely unknown. They work in a region of 'unknowable entities far removed from our ordinary conceptions'.

How do these revolutionary changes in our concepts of the physical universe affect the central theme of this discussion? These 'idealizing physicists' give no indication of the place held by living matter in their schemes. It appears that the cycle of physical events does not admit this aberrant form of matter. For Sir Oliver Lodge the ultimate reality is 'etheric periodic disturbances' which lie outside matter and the latter is manifested to us by its interaction with this periodic 'something'. Similarly the activities of life and mind are traced to these etheric waves of high frequency, and they are supposed to be the physical basis of life and mind. The attributes of guidance, direction, and control are imparted to these etheric waves which differ from other metaphysical concepts like 'elan' and 'entelechy' in having a physical structure. In order to avoid controversy and 'to keep out the prying philosophers', Eddington has excluded 'consciousness' and other processes of the mind from his picture of the physical universe while Lodge, like Whitehead who looks upon the universe as a kind of organism, has endowed the ether with attributes of life.

These modern conceptions of the physical universe have indicated a return to idealism and give no suggestion about the mysterious nature of living matter. Life is regarded either as an accident, a disease of matter or it is left out of any consideration whatsoever. The oft-quoted saying of Goethe 'I have no name for it; it is all feeling' signifies their attitude.

PHYSICS AND CHEMISTRY OF THE PROTOPLASM.

Before we can understand these mysteries of life, it is necessary to study living matter in all its aspects with the help of the tools and appliances with which we have probed into the other mysteries of nature. Scientists were not slow in making a systematic attempt to study the chemistry and physics of living matter and when they did so, they received a rude shock—that living matter was not governed by the known laws of physical chemistry. The Principle of Donan Equilibrium cannot hold itself in the case of protoplasm. Living matter is never in a state of osmotic equilibrium with the surroundings. It maintains its dynamic equilibrium with the surroundings by the liberation of energy and fresh energy for the continuation of the dynamic equilibrium is always obtained from outside. Such examples of the unusual behaviour of protoplasm can be multiplied. Recently an attempt was made to show that the most important manifestations of life are governed by the physical properties of the protoplasm. The colloidal nature of protoplasm is considered to be its most important physical property; and many protoplasmic activities can be traced to the changes in the protoplasmic colloids. The death of protoplasm at high temperatures, the hæmolysis of blood cells and the cytolysis of eggs, the phenomena of salt antagonism, the action of salts, fat solvents, mechanical injury, and electrical stimuli on living cells are also accompanied by, or caused by, the coagulation of the colloids of protoplasm. Similarly the other protoplasmic activities displayed in the amœboid and ciliary movements of protoplasm and stimulus movements of plants, and the process of cell division are now supposed to be dependent on colloidal changes in the protoplasm.

The importance of the molecular structure in the activities of the living cells has now been demonstrated in more than one instance and the efforts of the present-day biochemist to explain them in terms of molecular dynamics have met with considerable success. The rôles played by enzymes, hormones, and vitamins in plant and animal metabolism are now better understood than even before; and biochemists are following these three important entities while tackling biological processes with remarkable skill and patience. The enzymes are those mysterious structures which bring about many complex reactions and energy transformations by acting on the surfaces of the colloidal particles. They are both specific and selective in their action and bring about the synthesis of complex substances with an ease and perfection unknown in the 'laboratory of man'. Similarly the hormones and vitamins by their presence control and direct the normal metabolic activities of living organisms which in their absence would develop into unbalanced and monstrous forms. The knowledge of their chemical nature and behaviour is speedily growing and has been shedding light where a few years ago darkness prevailed.

Another promising line of attack towards the visualization of the functioning of living organisms is that of tissue culture experiments in which small parts of living tissues separated from dead or living organisms are nourished and kept alive for an indefinite period. The whole technique of these *in vitrio* experiments is so much refined and elaborated that the processes of growth, cell division and reproduction can be directly observed and the behaviour of cells can be studied under specially controlled conditions. None would have dreamt a few years ago that an embryo heart from unhatched eggs, and cut into small fragments, could continue to beat for a considerable time after its removal or that the processes of bone formation in microscopic tissue could be watched separated from the body of the organism. These experiments shake one's belief in the holistic philosophy. For in this case a small part of an whole can be made to go on existing intact and pass through all the operations which it normally goes through in a complete whole.

II.

TWO FUNDAMENTAL PROCESSES.

As one germ of life gives rise to another, one thought becomes the precursor of another. The domain of the inorganic is characterized by two opposite and antithetic processes. The first is the process of consolidation by which the units of electrical energy have consolidated into matter. This process has very probably occurred in regular sequence as can be seen from the atomic numbers of the different elements which range from one to ninety-two. The majority of physicists would dissent from the view that the radiations consolidate into matter. The second process is that of expansion by which the matter is transformed into radiations. A mass always gives off radiation or energy. Some condensed masses of matter give off energy more rapidly than others. The astrophysicist tells us that as a star gets older, its mass decreases and the disappearing mass leaves the star in the form of radiations. So the tendency towards the expansion of the consolidated energy is not suppressed and it manifests itself in greater degree in some cases than in others. Radioactive elements bear witness to this fundamental process going on in the inorganic universe. Though it is comparatively easy to assume that condensation of radiations into mass has occurred, it is not possible to explain the process and like all natural processes it has defied human efforts at imagining the astronomical conditions under which it has occurred. We have to wait for further illumination from the physicists before we can in any way know more of the process, and the recent discovery of the position may prove of great value in understanding it. But let us leave inorganic matter and see if the same two processes of consolidation and expansion also characterize and govern the living matter.

NEW UNIT OF LIFE.

The cell with its protoplasm is no longer regarded as the unit of living matter like the atom of the older chemists. The nucleus controls the actions and reactions occurring in the cytoplasm and itself contains these stainable bodies called the chromosomes which are in turn made up of genes. These genes determine the hereditary qualities of a plant or animal. Though these genes are too minute to be visible under the microscope, their existence is fully demonstrated by breeding experiments done on plant and animal organisms. The smallest living organism is much smaller than the ordinary bacteria known to us. It is so small as to pass through filters. The bacteriophages, which, as recent experiments have shown, belong to distinct races, attack and break up living bacteria, and are regarded as living organisms much smaller than the genes. It may be a progene, and the bacteria and cocci have evolved by the aggregation of these primitive genes. The size of the bacteriophage is supposed to vary from $8\mathrm{m}\mu$ in diameter to $250\mathrm{m}\mu$ although some of these may be made up of an aggregation of many genes. The bacterial organisms form the next stage in the order of living organisms which, though they do not visibly contain the nucleus, contain the free genes located on the scattered chromidia. The scattered chromidia come together to form linear chromosomes in the nucleus.

Thus we see that the gene and not the cell is of vital importance and therefore it is necessary to know something more about the gene. These genes are not merely geometrical points in the chromosomes but have variable magnitudes as the recent Russian experiments on the multiple allelomorphs in the fruit fly show. The gene is assumed to be in structure a chemical molecule or a group of molecules in a linear chain and the size of the gene correspondingly varies. According to the calculations of Muller the average size of the gene in the *Drosophilia* is about 48·5mμ and there are such 3,600 genes located in the four pairs of chromosomes found in this insect.

The invisible 'protogene' is the first manifestation of life on this earth, and the most pressing problem of the day in science is to discover the precise nature of the gene with reference to its structure and find out how it initiates, controls, and is able to carry on the complete chemical and physico-chemical reactions associated with life.

With the gene as the unit of life the problem of the nature of living matter is shifted from the visible to the invisible. The unimolecular genes have aggregated to form polymolecular genes. The genes have aggregated to form chromidia, the chromidia have aggregated to form chromomeres, and the chromomeres have aggregated to form the chromosomes. These are the real basis of life; the rest are the products of their activities. The protoplasm is a colloidal organic envelope which is the field of their activity.

Just as it is not possible at present to predict the manner and causes underlying the process of consolidation that has occurred in inorganic matter, it is equally impossible to say how the first consolidation resulting in these genes or their precursors occurred.

There is another important similarity existing between the atomic phenomena and the biological processes. Like inorganic bodies, living matter gives off radiations. This was first noticed by Gurwitsch in 1926 who showed that living cells give off radiations which induce cell divisions in other cells; so he named them mitogenetic radiations. Like all startling discoveries his results, though they aroused great interest, met with great disbelief; but the repetition of Gurwitsch's work by the Russian scientists of Moscow and Leningrad has well established the fact that all living cells give off these mitogenetic radiations. These radiations are given out by our eyes, blood, and excited nerves and can be detected by measuring the increase in the number of yeast cells subjected to them. These invisible rays are now studied by physical methods and are found to be in the ultra-violet region between 1900 A.U. to 2500 A.U. They do not pass through glass but are able to pass through quartz. Besides, they can be split up by a quartz spectrograph into bands 10 A.U. wide and each band can be examined separately for its effect in terms of the increasing rate of division of yeast cells. These Russian scientists have gone a step further and claim that from the nature of radiations given off by the living cells it is possible to identify the nature of the chemical reactions involved in their activity by comparing the band spectra of living cells with that of various chemical reactions. It is also claimed that a fatigued person emits less amounts of these radiations from his eyes than a person who is quite fresh. If these results, now of course looked upon with a certain amount of suspicion, can be verified, then a new day indeed has dawned in the history of the biological sciences.

The discovery of these mitogenetic rays emitted by living matter leads us to fruitful channels of speculation. It is very likely that atomic energy is somehow utilized in the vital processes characteristic of living matter. In 1926, before I knew about this discovery of mitogenetic rays I advanced a similar view, though defective language obscured it. But suggestion in the same direction was made last year by Sir Fredrick Hopkins in his article on atomic physics and vital processes. If it is a specific property of living matter to utilize atomic energy, it is likely that the energy carried by a part of these radiations is absorbed and utilized in the complex series of reactions occurring in the protoplasm. The first impulse for the starting of these complex reactions is probably derived from the atomic energy which activates the molecules of the protoplasm and starts a rhythmic interplay with other molecules. This results in a structural change in which energy is absorbed and liberated and the original molecules are again set free to repeat the process. This rhythmic principle underlies all the important processes like the synthesis of proteins and carbohydrates, and respiration occurring in living matter. Life is defined by Hill ‘ as a self-perpetuating and generally periodic complex of events occurring in a medium of matter ’ ; and these self-perpetuating periodic events may have their origin in the periodic liberation of these radiations from living matter.

If the genes are regarded as the ultimate units of living matter, it is very probable that the radiations recorded are emitted by them. The protoplasm which was once considered the physical basis of life is really a product of these active molecules constituting the genes. A kind of colloidal envelope within the field of these units of living matter is produced; this envelope consists of activated molecules of inanimate matter. The reactions of these molecules have become so organized that the envelope maintains its dynamic equilibrium with the external environment. In the course of evolution these reactions have also become specific for each cell or organism so that they impart a specificity to the cell or the organism. The multiplicity of living forms can be traced to the different structural arrangements of the molecules comprising the genes. We have no idea about the chemical nature of these genes but they possess unique properties not exhibited by the other known atoms and molecules. This is not unlikely, in view of the fact of the carbon atom possessing remarkable properties of binding atoms together, of the magnetic properties of iron and of the radioactive properties of radioactive elements. These atoms do not differ from their respective neighbours in the periodic system, except that the atoms of these elements have one or two electrons more or less than the latter. It is very likely that atomic physics may ultimately trace the remarkable properties, exhibited by living matter, to the wonderful play of electrons in the loops of the atoms.

Before the protoplasm can yield to the valiant efforts of able workers and disclose its inner nature, the discovery of the genes as units of life has shown, much to our discomfort, that we were so far exploring only the neighbourhood of the main fortress. We are still not in close grips with the real units of living matter which lie hidden in the mass of the protoplasm. Considerable difficulties have been experienced to get at the elemental stuff of protoplasm for investigation. It will be well nigh impossible to establish direct contact with these genes which are responsible for the minutest detail of the structure of an organism like the colour of the hair or the eye. Efforts may now be concentrated on these important bodies in the living cells and the discovery in America in 1927, that the genes can be modified by treatment with X-rays, is of great significance in that it is suggestive of the methods to be applied for finding out the structure of these bodies. Just as the transmutation of atoms is brought about by their bombardment with particular particles or penetrating radiations, the genes can be so modified by exposing them to radiations like the X-rays that they cause structural peculiarities different from the original ones in the parent organism. The egg of a fly which would have normally developed into a red-eyed individual when irradiated will develop into an individual with white patches in the red eye. If the structure of atoms, molecules, and crystals can be disclosed by the application of the X-ray analysis method, will it be pure speculation to expect that some information may similarly be gained about the structure of the genes ? A notable effort has already been made by Bragg and his school by applying this device to the study of the molecular arrangement of the organs and parts of the living body. So far efforts have been made to study only the diffraction patterns of parts like the hair, nerves, muscles, and tendons, and the arrangements of these molecules are determined ; but is it too much to hope that methods will soon be devised to study the arrangements of the molecules composing the genes ?

The characteristic feature of the living organism is its capacity for growth and reproduction ; any view that seeks to explain the nature of living matter must account for these specific behaviours. The processes of growth and reproduction have proved stumbling blocks to all who have speculated on them ; and both the mechanistic and the holistic theories of life have failed to explain them.

If the protoplasm is merely the product of the activity of the genes, the whole body of a multicellular organism, which is really an aggregate of these protoplasms, is also a product of the same activity. The germ of an organism contains the necessary genes with definite structural arrangements of their molecules, surrounded by the colloidal envelope of the cytoplasm. By a series of reactions with the external medium and in the formation of the same type of cytoplasmic envelope followed by its regular partition, the same sequence of events reoccur, and ultimately the whole organism of that definite pattern, foreshadowed in the structural parts of the units of living matter, is produced. The genes initiate the process and the rest follows. They supply the moulding force, giving shape and form to living things. The main difficulty lies in understanding how the genes reproduce themselves. Every cell division is preceded by the division of the genes linearly arranged on the chromosomes, and their mass must be doubled prior to division. This can only be done by the transformation and incorporation of non-living matter into their mass, and should be of such a nature that the structural differences in the genes of an organism are exactly reproduced. This is the main difficulty to be faced. If the genes are not reproduced, the fundamental assumption of Biology, viz., 'Like begets like', will be falsified. If the genes reproduce themselves from inorganic matter, we are faced with physical difficulties; for the gap between what we call living matter and non-living matter remains unbridged. We do not yet understand the dynamics of the movement of a simple thing as the amœba; much less do we understand why it divides.

It is now known that the variation in the structure of living organisms arises as a result of the rearrangement, aggregation, and loss of the genes. In the intervarietal differences few genes are involved; while the interspecific differences are caused by a large number of them. The variations may also arise by the increase in the normal number of chromosomes and consequently of the genes, by the phenomena of non-disjunction. The geneticists do not, however, regard the variations arising from these causes as important or true mutations. They attach great importance to the changes that arise as a result of changes in the genes, and called by them 'gene mutations'. We have no knowledge how these 'gene mutations' arise. It may be that they arise when they are reproduced at the time of cell division, as during reproduction the two daughter genes may not be exactly of the same pattern, and may show structural differences from the parent gene. Thus when a gene in all its detailed structure is not reproduced at the time of cell division, the gene mutations, or sometimes the so-called new genes, are produced and a slight change in the structure of a gene may produce visible differences in the structure of the organism. *If it is true that genes with slightly* *different structural patterns, are produced at the time of partition, the origin of variations can be satisfactorily visualized. The loss of genes may also then be said to be taking place on account of the failure of reproduction.* It was mentioned above that when the seeds or reproductive bodies are exposed to X-rays or other radiations, the organisms developed from them show marked differences from the parental forms. These differences are probably due to the structural changes produced in the genes as a result of such treatment. It is therefore not unsafe to assume that structural changes occur in the genes at the time when the genes grow and divide prior to cell division.

May it not be that these genes by giving off radiations follow the Law of Expansion I have referred to above? The physicists speak of the annihilation of matter due to the increase of entropy. · Will this one day prove to be true of the genes that by their unique properties and behaviour are in the ultimate, so far as the human analysis can reach, responsible for the whole drama of life?

If the genes, units of what we call living matter, by the complex working of their energy incorporate and transform the so-called inorganic matter into their own substance, thus producing things like the protoplasm, cells, tissues and organs, how could life be defined except as the rhythmic interplay of the energy of these radiations with its environment?

This is the extent of our present knowledge and speculations about living matter. To disentangle every thread of this tangled maze will require the supreme efforts of a large number of scientists; and it will be very long before we shall be able to visualize the chain of events occurring in a minute speck of matter with which life is associated. The nature of living matter is no longer a problem exclusively for the biologist. It has passed into the hands of the chemists and I am sure the latter have learnt new lessons in chemistry while investigating it. But so far the biochemists have not really been working with the genuine units of living matter, they work but with the products of their activities. It is difficult to foretell what secrets chemical investigations of the real units of living matter will disclose. The discovery of the genes and their modifications by the X-rays leads us to expect that the problem of the nature of the living matter may become a problem for the physicists and thus may ultimately become a problem for all the sciences.

There can be no branch of human knowledge which is more important to human progress than that branch of knowledge which aims at elucidating and interpreting what the 'living' is and every human effort should be directed towards that sublime goal. A man cannot be said to be truly living if he does not try to know what the living is. That is the one criterion at least one would be inclined to separate man from the lower animals, and those men and women who contribute towards serving this end shall in the noble words of the King of the Brobdingnagians 'deserve better of mankind than the whole race of politicians put together'.

Much has been said, sometimes rightly and sometimes in a spirit of acrimony, about the evils of the present-day science to the human race ; but the biological sciences should be free from such indictments. A knowledge of life must help the causes of human betterment and progress. This has got an ethical value and will raise mankind towards the highest level of perfection. But this knowledge can never be obtained by flights of imagination, however rich and powerful they be. Nor would it come to us in the visions of a poet or in the speculations of a philosopher. It can be obtained only by the constant effort and the steady zeal of those that are engaged in this noble pursuit of finding out truths that lie behind the structures and functions of the phenomena of nature—now understood by some and therefore seen in terms, the living and the non-living. To this end the science of the future shall be directed and it may even be that the science of life will some day give new life to all the sciences.

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Section of Botany.

Abstracts.

ALGÆ.

1. A new Nitella from Assam. *Nitella Grovesii* Kundu, Sp. Nov.

B. C. KUNDU, Rajshahi.

In 1926 the author went to Shillong and collected a few Charophytes. The specimens have been identified. Two of the specimens collected from Shillong were found to be very interesting. They are the male and female plants of a diœcious species of Nitella. They possess dactyls containing three cells. J. Groves in his 'Notes on Indian Charophyta' mentioned only one diœcious species of Nitella—(*Nitella myriotricha* Kütz. prox.)—which has got three cells in the dactyls.

Portions of the male and female plants were sent to the late Mr. J. Groves in two tubes for correct determination. He identified it as a new species. Male and female plants have been described in detail.

The species is named after the late Mr. J. Groves, the well-known authority on Charophyta.

2. *Chara canescens* Loisel. from Nepal.

B. C. KUNDU, Rajshahi.

Among the many specimens which Dr. Agharkar collected from Nepal, were a few tubes containing specimens of Charophytes. The specimens of Charophytes were placed at the disposal of the author. Among these specimens the writer found some fruiting plants of *Chara canescens* Loisel. It is conspicuous by the presence of beautiful spine cells which can be seen even with naked eyes. Although *Chara canescens* occurs widely in Europe, Africa and America, it is not very common in India. In India it has been recorded from Baluchistan and Peshawar. A detailed account of the vegetative and reproductive parts is given in the paper.

3. Charophytes of Bengal—II. Charophyte notes from the district of Rajshahi, Bengal.

B. C. KUNDU, Rajshahi.

The district of Rajshahi, situated at a distance of 161 miles from Calcutta, is found to be rich in Charophytes. At the beginning of the present year (1933) the author collected a number of Charophytes from different parts of the district. All these specimens have been collected from shallow ponds and jhils which are filled up with water in the rains but usually dry up during summer.

In the present paper an account has been given of 14 species of Charophytes belonging to the four genera—Nitella, Nitellopsis, Lychnothamnus and Chara.

The following is the list of Charophytes collected :—

Nitella acuminata Braun.
N. mucronata Miquel.
N. sp.
N. furcata Agardh.
N. sp. nov.
N. hyalina Agardh.
Nitellopsis sp.
Lychnothamnus barbatus Leonh (?).
Chara Braunii Gmel.
C. sp. nov.
C. hydropitys Reichb.
C. fragilis Desv.
C. brachypus Braun.
C. zeylamica Willd.

4. Census of Indian algæ; Chlorophyceæ.

K. Biswas, Calcutta.

This is the second part of the paper under the heading noted above. The first part has been published in *Revue Algologique*, Tom. VI. Fascicle II, 1932. In this part, along with the census of species the author discusses in general the habitat of the green algæ, their cultivation and succession of some of the species. Attempts have been made to record all the species of Desmidiaceæ published up to date.

5. Algal contents of Aulocades larvæ.

K. Biswas, Calcutta.

Aulocades larvæ were discovered by Dr. S. L. Hora during his exploration of freshwater fauna of the Kalijhora stream at Kalijhora, Teesta Valley, in April, 1933. These larvæ were found lodged under the cobwebby mat of Algæ which supply food and shelter. The cobweb is mostly composed of *Schizothrix lacustris.* Filaments of a sterile *Spirogyra sp.*, several species of *Diatoms* and *Cosmarium granatum* were found on bed of *Schizothrix lacustris.* They have also been found in the guts of Aulocades larvæ. Diagnoses of these Algæ and the nature of their habitat has been discussed in the present paper.

6. A collection of Diatoms from the river Sutlej at Canal Head Works, Rupar.

M. Abdul Majeed, Lahore.

A large number of specimens were collected in tubes, during the months of November and December, 1932, from the Sirhind Canal Head Works at Rupar and an area of nearly one mile round about in the river Sutlej.

In this paper a list of 21 species, representing nine genera, with details of specific characters are recorded and figures given.

Some of the species showed auxospore formation.

7. Effect of the predominance of Desmidiaceæ and Myxophyceæ upon Diatoms.

M. Abdul Majeed, Lahore.

During his field observations last year the writer has been struck with a remarkable phenomenon regarding the paucity of the Diatomaceæ.

A careful study of the algal material collected from numerous pools and ponds in the districts Sialkot, Gujranwala, and Jullundur leads the writer to conclude that the predominance of numerous species of Desmidiaceæ and Myxophyceæ has a marked effect upon the growth and propagation of the Diatoms, so much so that in some cases it has rendered the existence of the latter quite difficult. Especially in pools at Daska and Ghartal (Dist. Sialkot) and in the vicinity of Jullundur

City only minute species of *Navicula* and *Nitzschia* were found among the material collected therefrom.

8. On some halophilous and halotolerant algæ from the Sambhar Lake, Rajputana.

S. L. GHOSE, Lahore.

In this paper the following algæ from the Sambhar Lake are described :—

Dunaliella salina Teodoresco; halophilous, does not die even in 27°B. brine.

Aphanothece halophytica Fremy; also halophilous, can flourish up to 25°B., remains dormant in higher concentrations and can revive on return of favourable conditions.

Anabœna sp.; halotolerant, becomes unhealthy at about 17°B., the heterocysts do not seem to lose their contents completely.

Arthrospira sp.; halotolerant, also becomes unhealthy at about 17°B.; flourishes more in winter.

9. Mosquitoes and Charophytes.

M. SAYEED-UD-DIN *and* ABDUS SALAM, Hyderabad, Deccan.

There is a controversy going on regarding the larvidal properties of Charophyta, and in the present note are put forward some of the observations that have been made by us in our laboratory on Chara (sp. ?), *Pistia stratioites* and on *Lemna* (sp. ?). These were grown in separate glass aquaria which were at first placed in a lighted corner, and were later on transferred to another corner a little away from direct sunlight. Observations were made for about a fortnight and during this time the water in each of the aquaria was changed about four or five times. After this the water was not changed at all, and further observations were made for over a month. What we have observed so far leads us to the conclusion that the aquaria containing Chara and Lemna produced about the same number of mosquito larvæ which was, however, very small considering the time allowed, whereas the aquarium containing *Pistia* had the largest number of mosquito larvæ in it. Although at this stage we cannot say that this particular species of Chara is a complete safeguard against the production of mosquito larvæ we can certainly say this much, that water containing Chara and Lemna becomes less infested with mosquito larvæ than that containing *Pistia stratioites*.

In the paper detailed observations are recorded and probable reasons for the appearance and non-appearance of the mosquito larvæ are given.

10. The Charophytes of the Dal Lake, Kashmir.

S. K. MUKERJI, Lucknow.

In the course of an intensive study of the vegetation of the Dal Lake of Kashmir, the author has had ample opportunities of studying the charophytic flora of this lake. In this paper he records the three genera and eleven species, viz. *Chara fragilis*, *C. brachypus*, *C. zeylanica*, *C. flaccida*, *Nitella acuminata*, *N. dispersa*, *N. mucronata*, *N. microcarpa*, *N. hyalina*, *N. furcata*, and *Nitellopsis obtusa*. A few of these species have also been collected previously from this lake by G. O. Allen and R. R. Stewart.

In the identification of these Charophytes the papers of James Groves and G. O. Allen have been of the greatest help to the author.

Further the specimens have been compared with the material at Kew, and with specimens kindly presented to the author by Mr. Allen who had them previously confirmed by the late Mr. James Groves.

FUNGI.

11. A study of a fungus causing loss of opium in storage.

J. N. RAY *and* H. CHAUDHURI, Lahore.

A fungus very much allied to *Scopulariopsis brevicaulis*, var. *glabra* Thom., has been isolated from several samples of stored opium from the Government Opium Factory, Ghazipore. This has been grown on various media in agar and gelatine and also in Challenger's liquid medium containing known quantities of morphine. By careful analysis, it has been proved that this fungus has definite power of living on morphine. Growth characters under different physiological conditions have also been studied.

12. Indian Slime-moulds.

SHER AHMAD, Lahore.

In this paper the slime-mould collection of Mr. and Mrs. Drake of Serampore, Bengal, has been fully worked out.

13. A short note on the presence of clamps in the sporophore of *Ganoderma lucidus* (Leyss.) Fries growing in nature.

S. R. BOSE, Calcutta.

Corner, of Singapur Bot. Gardens, doubted the presence of clamps in the generative hyphæ of all xanthochroic (yellowish-brown) specimens of *Polyporaceæ*. In fresh specimens of *Ganoderma lucidus* collected during the rainy season, I could get clamps in the living generative hyphæ after very careful teasing under the dissecting microscope direct from the white surface-layer of the hymenial side and very laborious search under the immersion-lens. A large number of preparations had to be examined from day to day to confirm the presence of clamps.

14. On a new species of Saprolegnia parasitic on fish.

H. CHAUDHURI, Lahore.

A new species of Saprolegnia has been described. It is parasitic on *Belone cancinula*. The infected fish dies ultimately. Zoospores in zoosporangia borne on the fish are usually not liberated but germinate *in situ*. When put in distilled water, however, the zoospores are freely liberated.

15. On endotrophic fungi in certain liverworts.

H. CHAUDHURI, Lahore.

Previously the author described the endotrophic fungus in Marchantia and also in Petalophyllum. In this paper the fungus in Athalamia and Aitchisoniella has been studied and its relationship with the host discussed.

16. Phytopathology in Ancient India.

H. CHAUDHURI, Lahore.

A short historical study of the subject has been made and the methods of controlling of diseases in Ancient India have been described and discussed.

17. A study of certain *Fusaria.*

A. K. Mitra, Allahabad.

A study of six species of *Fusarium*, belonging to three different sections, showed that with all the species a progressively better development was obtained in the following order of the media—apple agar, Brown's-starch, bajra agar, and potato-glucose. *F. viride, F. camptoceras*, and *F. moniliforme* which showed parasitism on potato, bajra, and apple respectively, not only did not show greatest development on the media prepared from the substance of their respective hosts but also did not show any difference indicating a greater suitability of those media for their growth than for other saprophytic species. In nature the characters of *F. camptoceras* were more developed and those of *F. incarnatum* less developed than on any of the media. Chlamydospores produced by *F. viride* were distinctly less abundant on a poor medium like apple agar than on a richer medium such as potato-glucose. Saltants differed from their parents in such characters as linear rate of spread, aerial mycelium colour of the substratum, sporulation, average septation, size of the spores, and abundance of the chlamydospores.

18. Some diseases of apples in Kashmere and the Punjab plains.

Lal Singh Chhina, Lahore.

Cankers, leafspots and fruit rot due to three different organisms, viz. *Macrophoma malorum, Sphæropsis malorum*, and *Cytospora* species have been studied. The causal organisms have been isolated and a comparative study under different physiological conditions made.

19. Leafspot disease of rice.

Jagjit Singh, Lahore.

Leafspots caused by *Helminthosporium halodes*, var. *oryzæ, Helminthosporium* nov. sp., and *Acrothecium lunatum* have been studied. Similar symptoms are found in all these. Growth in culture has been studied in each case under different physiological conditions and factors determining saltation and zonal growth have also been studied. All these fungi over-winter on seeds and also on some wild grasses. Inoculation experiments have shown that they can infect uninjured healthy plants.

20. Stem-rot of rice caused by *Sclerotium oryzæ.*

Jagjit Singh, Lahore.

The disease is evident in later stages only, when rotting of the basal part containing wefted mycelium and sclerotia sets in. In some cases late tillers may be seen. Artificially inoculated plants, in some cases, showed sclerotia formation even on roots. Results of inoculation experiments show that only young plants get infected and also different varieties of rice show different degrees of susceptibility.

21. Copper blight of tea.

J. S. Anand, Lahore.

The causal organism *Guignardia camelliæ* was isolated from the tea leaves in Kangra Valley. The physiology of the fungus under different cultural conditions has been studied. Perithecia are abundantly formed in many media. Inoculation experiments showed that it is only a wound parasite and that the disease spreads quickly at higher temperatures under moist conditions.

22. Internal root disease of tea.

J. S. Anand, Lahore.

It is caused by *Botryodiplodia theobromæ.* Though a weak parasite on other trees, it causes a serious root disease of tea. In this paper the physiology of the fungus has been thoroughly studied and also its methods of attacking the host have been followed up and confirmed by inoculation experiments.

BRYOPHYTES.

23. Life-history of *Exormotheca tuberifera.*

Sultan Ahmad, Lahore.

Material was collected from Mussoorie, Dulchi Pass, and Simla. All the stages in the development of the plant have been carefully followed and described.

24. Life-history of *Athalamia pinguis.*

Md. Ashraf, Lahore.

Complete life-history has been worked out, based on materials collected from Simla, Kulu, and Mussoorie.

25. Observations on *Petalophyllum indicum* Kashyap.

B. R. Vasisht, Lahore.

Some plants have been found resembling Fossombronia in habit. In the apical region the wings on each side consist of distinct leaf-like lobes with slight fusion at the base only. The anterior margin of the leaf is covered by the posterior margin of the leaf in front (succubous arrangement). In young plants also it has been noticed that the wing is formed of a few separate leaves arranged in succubous manner. In some cases the leaves are fused to about half the distance forming distinct lamellæ on the dorsal surface. It appears, therefore, that the peculiar structure of *Petalophyllum* is due to the fusion of the leaves which were arranged originally in a succubous manner and the lamellæ are simply the posterior margins of the leaves, since the anterior margin of a leaf is fused with the under-surface of the leaf in front. The direction of the lamellæ also supports the view. *Petalophyllum,* therefore, is closely related to *Fossombronia.*

Regeneration. Wings were cut from the midrib and involucres were also separated from the plants. They were placed on moist soil or in Knop's solution. All showed a remarkable power of regeneration. Buds were formed in the margins as well as on the surface of the wings. Five to seven buds or even more may be produced on one wing. Wings from older plants bearing sporogonia develop fewer buds or no buds at all. Each bud can be traced to a single cell. The divisions are subject to considerable variation, but usually the first division is transverse, separating a lower cell from the upper. In the lower cell no further division takes place while the upper cell forms a cell mass.

In one specimen a seta-like outgrowth has been observed growing from the wall of the sporogonium. The apex of the outgrowth was slightly greenish. In another sporogonium in a longitudinal section an outgrowth at the top of the sporogonium exactly opposite the seta has been found.

26. The spermatogenesis of *Notothylas levieri* Schiffner. MS.

S. K. Pande, Lucknow.

This paper deals with the spermatogenesis in *Notothylas levieri*. The resting cells of the young antheridium contain finely granular cytoplasm and a prominent and large nucleolus. In the early stages of the division of the antheridial cells the spindle coincides with the long axis of the cell and its threads are distinct. The spermatids are either triangular or semicircular in outline and the nucleus lies near the broadest side of the spermatids. In a fairly large number of preparations a blepharoplast-like body was seen.

The gametophytic number of chromosomes is about four.

PTERIDOPHYTES.

27. The morphology of *Ophioglossum fibrosum* Schum.

P. Maheshwari *and* Bahadur Singh, Agra.

The plant body consists of a tuberous rhizome with thin fleshy roots radiating downwards. There are 2–5 leaves. The spike arises from the petiole at its junction with the lamina.

The root steles vary from monarch to triarch. There is a distinct endotrophic mycorrhiza in the outer cortex. Growth occurs by means of a tetrahedral apical cell.

The rhizome has a single apical cell. The vascular skeleton is made up entirely of leaf-traces. Each leaf is supplied with two bundles, which lower down in the rhizome join to form a commissure from which a single root trace is given off. In transverse section the rhizome is made up of a reticulum consisting of leaf-traces, commissures, and root-traces.

The two leaf-traces, as they go up into the petiole, divide to form a ring of bundles. Four or five bundles from the adaxial side branch off to supply the spike.

The wall of the sporangium consists of the epidermis, a 3–5 layered hypodermis and the tapetum which is usually two layers thick. The tapetal cells disorganize to form a periplasmodium.

The spore mother-cells undergo the usual reduction divisions to form tetrads of spores. The mature spores are tetrahedral and uninucleate and have a fairly thick exospore. Dehiscence in the sporangia occurs by a transverse cleft appearing on the outer side.

28. Germination of the spores of *Ophioglossum* of Poona.

D. L. Dixit *and* T. S. Mahabale, Poona.

At the suggestion of Prof. D. L. Dixit a detailed study of the various species of *Ophioglossum* found in these parts was undertaken in 1931, on which the present paper is based. It is a concise statement of the methods used to obtain the prothallus of this plant.

All factors, such as cytological probabilities, soil and fungus, distribution, dispersal and fate of spores as found in nature, and such others were critically studied, which disclosed the fact, that the spores germinate in nature only in association with a special fungus. This view was strengthened by further observations on similar lines and was also verified by cultural methods in the laboratory in which prothallii have actually been obtained from spores kept under observation. Further researches are still in progress.

29. *Ophioglossum* Sp. near about Poona.

D. L. Dixit *and* T. S. Mahabale, Poona.

Among the plants of *Ophioglossum* that have been collected from different places in Poona District, some are extremely small and grass-like, being often confounded with grasses. They offer many morphological peculiarities which make it very difficult to place them under any of the species described.

The root-stock is either slightly tuberculated, globose, or elongated and jointed below. Brownish sheaths are present while the roots are very few, being thicker and longer. The sterile segment is $\frac{5}{8}''$–1″ long and 1-2 lines broad. Apex is acute and texture thick. Midrib is recognizable. Two or three veins run parallel from the base towards the apex where they are slightly reticulated. The rootstock being thus of a varied form precludes the possibility of the plant being referred to any of the Indian species, each of them being characterized by the possession of a special form of rootstock. The brownish sheath and the parallel veins show its affinity to *O. fibrosum* (Schum.) from which however it differs in the form of the rootstock, the rootlets, and the breadth of the sterile segment. It approaches in many respects *O. gramineum* Willd. but differs from it in the nature of the rootstock and the presence of a midrib even if we neglect the veins and veinlets.

It, therefore, appears to be a new species or a very distinct variety of *O. gramineum* Willd.

30. Variability of parts in the genus *Ophioglossum.*

T. S. Mahabale *and* G. S. Deshpande, Poona.

In our field observations on *Ophioglossum* we were surprised to find a very wide range of variability of parts in different members of the genus. At the suggestion of Prof. D. L. Dixit we have collected about 30 abnormal specimens showing pleiogeny (bifurcation, fission, etc.). Detailed morphological account of these specimens is given and some important generalizations have been drawn as to the inter-relationship of different Indian species of *Ophioglossum.* Analysis of variability factors is made so as to throw a side-light on the nature of the present-day taxonomical criteria adopted for the genus. It is suggested that this external variability must have a strong internal complement which is being worked out.

The specimens will be exhibited.

31. Polarity of sexual reproductive regions in *Selaginella.*

D. L. Dixit, Poona.

If in animals it is the ova that generally exhibit polarity, in plants like *Selaginella* it is the asexual cells that show a kind of functional as well as structural polarity. The angular pointed end of the mega- or microspore (being directed, at its formation, towards the point of intersection of the three planes in which the mother-cell divides) is possibly its passive or inactive pole, its blunt end, in which the nucleus lies, being the opposite active pole. The two kinds of sexual plants, that these spores respectively produce, are differently situated in them in relation to the poles. The male plant which is produced in the microspore is situated with its vegetative portion directed towards the passive angular pole, and its antheridial part in the blunt active end. The female plant, on the other hand, is produced in the megaspore in a position which is quite the reverse of what is obtained in the microspore, viz. that its pure vegetative portion is placed in the blunt end while its archegonia-producing region is directed towards the angular end. Thus, the two kinds of sexual reproductive regions in the two gametophytes of *Selaginella* occupy two opposite poles in their respective spores in answer to the two opposite functions to be performed by the two reproductive cells that they give rise to.

32. Sporogenesis in Marsilia of Poona.

G. G. Kolhatkar, Poona.

The sporogenesis of Marsilia—a member of the Hydropterideæ—is studied. The spores are of two kinds and are produced in a special organ called the sporocarp.

The sporocarp which is a biconvex capsule is divided into 12 to 14 compartments, each bearing one sorus. The sorus lies lengthwise and transversely on the wall of the sporocarp and bears both mega- and microsporangia. A detailed study of both mega- and microsporangia has revealed the fact that the formation of sixteen tetrads takes place on identical lines in both of them. But later on 64 microspores are produced in the microsporangium, while in the megasporangium only one cell from each of the many tetrads becomes larger in size and the remaining tetrads show signs of rapid degeneration. Ultimately one cell from one of the tetrads becomes largest and is very soon converted into the megaspore.

Thus our observations agree with those of Goebel rather than with those of Bower, Campbell, Pandya, and others.

GYMNOSPERMS.

33. A study of the male gametophyte of *Ephedra peduncularis* Boiss. in artificial cultures and the number and morphology of the chromosomes.

P. N. Mehra, Lahore.

The pollen grains of *Ephedra peduncularis* Boiss. have been germinated artificially, on the mucilaginous fluid that oozes out of the micropyle of the mature ovules, on a glass slide, placed in a moist chamber. The pollen grain at the time of dehiscence of the anther contains a stalk nucleus towards the ephemeral vegetative cell, a generative cell, and the tube nucleus at the opposite end. During germination the pollen tube may be given off from any side of the grain though rather less frequently from the end where the vegetative cell is cut off. Two or three tubes may frequently be given off from a single grain and these may even branch. The contents pass through one of these only. The rest remain empty.

The study of the chromosomes was made during the division of the generative nucleus in the formation of the two gametes. The haploid number is definitely seven. Three of these, A, B, C, possess the median fibre attachment constriction; two, D and E, submedian constriction with the longer shaft about 1½ times the shorter one and D is larger in size than E; two, F and G, possess subterminal fibre attachment constriction with only a knob at the interior end.

Further work on other species of Ephedra in this connection is in progress.

ANGIOSPERMS.

34. *Croton sparsiflorus* at Benares.

A. C. Joshi, Benares.

This plant came to India only very recently, about the end of the last century. Brühl has given a history of its introduction round about

Calcutta. At present in the East it has become widespread in Assam. Haines some time ago recorded it from Bihar and Orissa and now the author has been seeing it for the last two years at Benares. It is especially common on the banks of the Ganges, and river-beds seem to be the main path of spread of this species.

35. Morphology of the stylar canal in Angiosperms.

A. C. JOSHI, Benares.

The relation of the stylar canal with the main vascular strands in the carpels of four families, Nyctaginaceæ, Phytolaccaceæ, Thymelæaceæ, and Ficoideæ, is traced. From this study it is concluded that the stylar canal or the conducting tissue of the style occupies the place of and represents modified ventral traces of the carpel.

36. Some observations on the morphology of *Rivina humilis* Linn.

A. C. JOSHI, Benares.

The carpel of Rivina develops from one side of the nucellus and finally encloses it. During its development it shows a 3-lobed phase and it grows chiefly from three points in three directions. This gives support to the hypothesis of Dr. Thomas that the original carpel of Angiosperms was a 3-lobed palmate structure.

Microsporogenesis is normal. Pollen output per anther is between 800–1,000. The mature pollen grains are trinucleate.

Ovule possesses two integuments, there is a single hypodermal archesporial cell. It cuts off a wall cell which gives rise to a large amount of parietal tissue. The megaspore-mother-cell forms only 3 megaspores. The lowermost of these is the functional one.

Embryosac is of the normal 8-nucleate type. The synergids have elongated and pointed apices. The three antipodals persist up to 4- or 5-celled stage of the embryo. Polar nuclei fuse at an early stage.

Endosperm nucleus divides before the oospore.

37. Micro- and megasporogenesis in *Calotropis procera* R. Br.

S. L. GHOSE *and* S. S. BHATIA, Lahore.

Microsporogenesis.—There are only two microsporangia to one anther. The tapetum arises partly from the sporogenous cells and partly from the vegetative tissue of the anther. Tapetal cells are uni- or binucleate. The archesporium consists of several long, radial cells arranged at right angles to the inner surface of the anther. The archesporial cells form the microspore-mother-cells directly without division. At synizesis the threads form a tight knot, in which they cannot be followed. The nucleolus which is otherwise spherical becomes amœboid at this stage. The spireme in heterotypic prophase remains connected with the nucleolus. The nucleolus fragments at diakinesis. The haploid number of chromosomes is ten and their formation is telosynaptic. The spindle is intranuclear and at first multipolar and then bipolar. Nucleolus disappears and is not seen at metaphase. The supply of the staining material to the spireme is not from the nucleolus exclusively.

Megasporogenesis.—Generally a single hypodermal archesporial cell is formed, but sometimes two are seen lying side by side. Only a single integument is developed. The megaspore-mother-cell is embedded in the tissue of the ovule. No tapetum is formed. The tetrad is generally in a row. Usually the lowermost megaspore functions but in some cases the uppermost does so. The division of the megaspore-nucleus is very rapid and the antipodals are quite conspicuous.

38. Development of the female gametophyte in *Moringa oleifera* Lam.

VISHWAMBHAR PURI, Agra.

This plant was first investigated by Rutgers in 1923 who reported a five-nucleate embryo-sac in it. As my observations are in some respects fundamentally different from those of Rutgers, they are briefly recorded here.

The nucellus has usually only one megaspore-mother-cell but often two or rarely even three are met with. In the earliest stage it is separated from the nucellar epidermis by one layer of cells. On reduction a tetrad of four megaspores is produced which may be linear or T-shaped. When two megaspore-mother-cells are present, they might both go through the reduction divisions and develop in the usual way, so that at maturity one can often find 'twin' embryo-sacs lying side by side or one above the other.

The chalazal megaspore functions and a normal eight-nucleate embryo-sac is produced in the usual way. There are three to four wall layers separating the embryo-sac from the epidermis but later on they disappear and in some cases even the nucellar epidermis may also be used up. The antipodal cells are extremely ephemeral and disappear very early so that the mature embryo-sac usually shows five nuclei. It appears that the antipodal cells were entirely overlooked by Rutgers either due to insufficiency of material or due to poor fixation.

The two polar nuclei meet in the upper half of the embryo-sac just beneath the egg-apparatus.

One case was noted in which two paired nucelli had separate inner integuments but were enclosed in a common outer one.

39. Development of the male gametophyte in *Hydrilla verticillata* Presl.

P. MAHESHWARI, Agra.

The male flower has three sepals, three petals, and three stamens with very short filaments.

After the anther becomes four-lobed, a plate of hypodermal archesporial cells differentiates in each lobe. The amount of sterile tissue in the anther is surprisingly small. The primary parietal layer gives rise to the endothecium, one or two middle layers and tapetum by periclinal divisions. The tapetal cells remain uninucleate. The microspore-mother-cells undergo two successive divisions and form isobilateral tetrads. The tapetal cells at this stage become amœboid and wander in between the microspores.

The microspore nucleus divides to form a tube and generative cell. The latter divides again and gives rise to two lenticular male cells. The pollen grains have a thin exine which has very delicate projections on the outside. The endothecium does not develop the usual thickenings, a fact in accordance with the aquatic habitat of the plant.

40. The life-history of *Mangifera indica* L.

P. MAHESHWARI, Agra.

The study was made from slides prepared by the late Dr. Dudgeon and placed at my disposal through the kindness of Mrs. Dudgeon.

The flower consists of 5 sepals, 5 petals, 5 stamens, and a single carpel. Usually only one stamen is fertile and the rest abort at an early stage. The ovary contains a single anatropous ovule, Differentiation of sporogenous tissue in the anthers is rather late. The anther wall consists of the epidermis, endothecium, two middle layers, and tapetum. About the time of the first meitotic division the tapetal nuclei also divide and the cells become binucleate. The divisions in the microspore-mother-cells are simultaneous and result in normal tetrads of microspores. The first division in the microspore cuts off a vegetative from a generative cell. The latter moves into the cytoplasm of the vegetative cell and divides later into two male nuclei which seem to be naked. There is an abundance of starch in the pollen grains.

The archesporial cell in the nucellus is so inconspicuous in its early stages that it cannot be distinguished with certainty till a few layers of wall cells have been cut off. Usually there is only one megaspore-mother-cell, but occasionally two are found in the same nucellus. Degenerations in the flowers are so frequent at this stage that it has not been possible to follow the stages in megaspore formation, but from the few slides the author has of this stage it appears that a normal linear tetrad is formed and the lowest megaspore functions. The mature embryo-sac is 8-nucleate and has the usual organization. The polar nuclei fuse early and the fusion nucleus lies very close to the egg. Due to periclinal divisions in the wall cells and the epidermis, the embryo-sac is deeply sunken in the nucellus.

41. Life-history of *Ranunculus sceleratus* L.

B. L. GUPTA, Agra.

Microsporogenesis.—In the very young stage the anther appears more or less oval in transverse section with two groups of archesporial cells. Each of these two groups divides into two by the appearance of sterile cells resulting in four groups of archesporial cells. By periclinal divisions the archesporial cells cut off a primary parietal layer which becomes two-layered. The inner of these forms the tapetum. The outer divides periclinally to form the endothecium and two middle layers. Most of the tapetal cells become two-nucleate when the microspore-mother-cells are in the synizesis stage. Some may become even three-nucleate. The divisions of the microspore-mother-cells are simultaneous and the resulting microspores are arranged both tetrahedrally and isobilaterally.

The microspore nucleus divides to form the generative and the tube cells. Later the wall dissolves and the two nuclei lie free in the cytoplasm of the pollen grain.

Megasporogenesis.—The archesporium differentiates very early. The number of archesporial cells, which are hypodermal, varies from one to three. These cells directly function as the megaspore-mother-cells. There is a single integument and the ovule is anatropous. There are indications that the megaspore-mother-cell, after the usual two divisions, forms a normal tetrad of four megaspores of which the lowest functions. If the number of megaspore-mother-cells in a nucellus is more than one, only one forms the embryo-sac while the remaining have not been observed to proceed beyond the dyad stage.

The nucleus of the functioning megaspore, after the usual three divisions, forms the normal eight-nucleate embryo-sac which, at maturity, enlarges so much that the surrounding cells are crushed and it lies immediately below the epidermis. At this stage or even earlier, usually three epidermal cells at the top of the nucellus divide by periclinal walls resulting in a two-layered epidermis. The polar nuclei meet near the egg to form a large fusion nucleus. The three antipodal cells continue to increase in size even after fertilization, but they remain uni-nucleate throughout.

42. Contribution to the life-history of *Trianthema monogyna* Linn.

H. R. Bhargava, Agra.

The anther shows the usual structure. There are three wall layers below the epidermis,—an endothecium, one middle layer and the tapetum which becomes binucleate. The microspore-mother-cells undergo two simultaneous divisions and give rise to tetrads of microspores.

On division of the microspore nucleus a lenticular generative cell and a large vegetative cell are formed. The nucleus of the former divides again so that the mature pollen grain is three-nucleate. The two male cells are spindle-shaped. Each pollen grain has three germ pores.

The young nucellus shows an archesporial cell which divides to form the primary wall cell and the megaspore-mother-cell. The occurrence of 2–4 archesporial cells is also common. The megaspore-mother-cell undergoes the usual reduction divisions to form a tetrad of four megaspores which are arranged in a longitudinal row. The chalazal megaspore functions, the other three degenerate. There are two integuments and the ovule becomes anatropous at a very early stage.

The nucleus of the functioning megaspore undergoes three divisions to form the eight nuclei of the mature embryo-sac which has the usual organization. The two polar nuclei meet nearly in the centre to form the fusion nucleus. There are three antipodal cells.

Later the wall cells degenerate and the mature embryo-sac lies just against the epidermis. The epidermal cells divide to form a five- to six-layered tissue but the four to five cells of the epidermis lying just above the embryo-sac do not divide but elongate radially.

43. Life-history of *Pedalium murex* Linn.

D. Ganesan, Madras.

Microsporogenesis.—The pollen-mother-cells mature and divide much earlier than the megaspore-mother-cell. At diakinesis eight bivalents are found. There is a perinuclear zone of dense cytoplasm. The mature pollen grain contains the tube and one generative nucleus.

Megasporogenesis.—The unicellular archesporium functions as the megaspore-mother-cell. The megaspore-mother-cell with a single epidermal layer of cells forms the nucellus. A linear tetrad of megaspores are formed, the chalazal one functions as the embryo-sac-mother-cell and the outer three megaspores degenerate.

The female gametophyte.—A nutritive jacket is formed by the innermost layer of the integument when the nucellus disappears. The mature gametophyte is an elongated sac. The synergids are beaked. The three antipodals are ephemeral and disappear before fertilization. The embryo-sac at this stage, except in the egg-apparatus and the antipodal regions, is filled with numerous starch grains similar to those found in the mature pollen grains.

Fertilization.—The pollen tube reaches the egg-apparatus 5–7 hours after pollination. Syngamy and triple fusion have been observed. The fusion of the male nucleus with the polars precedes syngamy.

Endosperm.—The primary endosperm nucleus divides soon after the fusion and by transverse wall formation a two-chambered embryo-sac is produced. The chalazal one functions as a haustorium which is later 4- or 5-nucleate. The micropylar one divides longitudinally. The starch grains of the sac which persist till this stage gradually disappear. By simultaneous nuclear division in the beginning, and wall formation, two rows of cells are formed. Later the endosperm has three distinct regions. The chalazal region has rows of converging cells with dense cytoplasm, with the shrivelled haustorium attached at the end. These cells are, after a certain stage, never in close contact with the integument. The middle region of much vacuolated cells, where the embryo develops, occupies the greater portion of the sac. In the micropylar region two rows of cells with deeply staining cytoplasm are found. Four cells near the micropylar end grow into the adjacent tissue. These cells form a secondary haustorium. The integument presents a much corroded appearance around this haustorium.

Embryo.—The fertilized egg rests till the endosperm is 8–10 cellular. The embryo has a very long suspensor.

Polyembryony.—In one case two embryos were found, one near the micropylar end with a long suspensor and the other lower down with a short suspensor turned towards the integument.

Fruit.—Though all the four ovules form embryos only one seed ripens in the fruit and germinates later.

44. Life-history of *Chenopodium album* Linn.

H. R. BHARGAVA, Agra.

Microsporogenesis.—Usually a single row of archesporial cells is found in each anther lobe. Occasionally a two celled row has also been met with. The archesporial cell divides periclinally to form the primary wall cell and the primary sporogenous cell. By further periclinal and anticlinal divisions the primary wall layer gives rise to an endothecium, one middle layer and the tapetum. The tapetal cells become binucleate. The nuclear divisions are mitotic and occur at the time when the microspore-mother-cells are in synizesis. The divisions of the mother-cells are simultaneous and both isobilateral and tetrahedral types of tetrads are formed. On division of the microspore nucleus a large tube cell and a small crescent-shaped generative cell are formed. At the shedding stage the nuclei lie free in the pollen grain which has a thick exine.

Megasporogenesis.—In the nucellus a hypodermal archesporial cell is differentiated which divides to form the primary wall cell and the megaspore-mother-cell. The occurrence of two to three megaspore-mother-cells is very common. The first division of the megaspore-mother-cell is followed by a wall and the second division results in the formation of a linear tetrad of four megaspores of which the chalazal functions. There are two integuments. While young the ovule is erect but after the differentiation of the megaspore-mother-cell it becomes completely inverted. The epidermis at the megaspore-mother-cell stage divides periclinally. The further development to the eight-nucleate stage presents no unusual features. The polar nuclei meet in the upper part of the embryo-sac below the egg. There are three antipodal cells.

45. Fruits and seeds in *Hibiscus rosa-sinensis*.

B. C. KUNDU, Rajshahi.

Last year (1932) a number of pollen grains of *H. rosa-sinensis* were used among others for the development of pollen tubes. They showed no signs of germination.

In April last the author observed three fruits on a plant of *H. rosa-sinensis* growing in a pot in the Rajshahi College garden. There were a number of other plants of the same species in the garden but none of them produced fruits. The writer watched them for two months and collected nine mature fruits from the same pot plant. It produced many flowers, but only a few of them developed fruits. From July to the 23rd September, 1933, the plant has produced no fruits, although it has been in flower throughout the time.

The fruit is a capsule containing a few seeds.

Germination of seeds.—On the 20th July, 1933, the author placed ten seeds collected from mature fruits in moist saw-dust for germination. Two of them showed signs of germination on 22-7-33 and on 25-7-33 two seedlings developed. After two days another seedling was noticed. The two cotyledons were seen to come out above the surface of the soil (epigeal). One out of these three seedlings died very soon and the remaining two are still growing.

A cytological investigation of the male and female gametophytes is in progress.

46. A manual of medicinal plants of Bengal.

K. Biswas, Calcutta.

The author, in this brochure, deals with the botanical aspects of the medicinal plants of Bengal. Illustrations of the plants have also been added with a view to guide the collectors in the field.

47. Viviparic mechanism in a superior fruit.

S. C. Banerji, Calcutta.

Aegiceras majus Gærtn, a viviparous species, is found at Canning forming a border of green verdure together with a species of Bruguiera along the swampy banks of the river. The mechanism with regard to the safe landing of the semi-germinated seed consists in the detachment of the seed from the tree prior to the fruit. The detachment is effected by the breaking away of the seed from the long basal funicle due to the jerk sustained by it when it assumes equilibrium after the dehiscence of the fruit. The ensiform macropodous seed is attached laterally to the funicle at the plumular end. The much longer and heavier radicular end hangs down when liberated from the fruit, and shows histological root-characters, and as such, it should not be regarded as 'hypocotyl' which is of stem-nature.

48. Some new species from Assam.

K. Biswas *and* P. C. Kanjilal, Calcutta.

While studying the papers left in manuscript by the late Mr. Debbarman and discussing the systematic position of some Assam phanerogamic plants in connection with the preparation of the Flora of Assam by the late Rai Bahadur Kanjilal and subsequently by his son Mr. P. C. Kanjilal and Mr. A. Das, the authors discovered some species which appear to be new to Science. Details of these species will be published along with the posthumous papers of the late Mr. Debbarman edited by the authors.

49. Systematic position of Sansevieria growing at the Royal Botanic Garden, Calcutta.

K. Biswas, Calcutta.

A species of Sansevieria has been recently cultivated at the Royal Botanic Garden, Calcutta. The leaves of this species are variegated and margins yellow-striped. The species was in flower during the month of May last, but no fruits developed. A similar specimen is mentioned in *Gardeners' Chronicle*, Vol. XLV, p. 347, 1909, as *S. laurentii* which has been reduced by Brown as a variety of *S. trifasciata* Prain. *var. Laurentii* N. E. Brown in *Kew Bulletin*, No. 5, p. 194, 1915. The writer considers that *S. trifasciata* may perhaps better be reduced to a variety of *S. nilotica* and the variety *Laurentii* to a garden form only.

50. A note on the occurrence of the parasitic Cuscuta on the plants of various families.

C. S. Krishnamurti, Agra.

The parasitic Cuscuta is commonly found on *Acacia arabica* (Mimosoidæ) and *Zizyphus jujuba* (Rhamnaceæ). But recently the author has discovered it to be growing on a number of plants belonging to various other families. It is curious to find this parasite infesting *Panicum sp.*, belonging to the Graminæ and therefore having silica in the epidermis, and *Euphorbia pilulifera* (Euphorbiacæ), which has milky latex. Besides these two families, the author has found the Cuscuta attacking the following genera, all belonging to different families: Cyperus (Cyperacæ), *Mollugo sp.* (Ficoidæ), *Tribulus terrestris* (Zygophyllaæ), *Cappaaris sepiara* (Capparidaceæ), *Blepharis sp.* (Acanthaceæ).

51. A note on the occurrence of bicarpellary pistils in *Sesbania grandiflora*.

C. S. Krishnamurti, Agra.

Normally the pistil in the *Papilionatæ* is monocarpellary, but last year in October the author observed a number of flowers of *Sesbania grandiflora* having bicarpellary pistils. The same tree showed both kinds of flowers, i.e. the normal flowers with the monocarpellary pistil and the abnormal one with a bicarpellary pistil. The plants were quite healthy and it was evident that this kind of abnormality was not due to any pathological condition. A number of seeds were collected from such abnormal cases in order to try them by growing this year. Similar anomalies have been recorded for many other genera of the Papilionaceæ by other authors.

52. An abnormal plant of *Raphanus sativus* Linn.

B. C. Kundu, Rajshahi.

The writer collected an abnormal plant of *Raphanus sativus* from a vegetable garden at Rajshahi in January last. The stem and root are really very curious. The stem is divided into three distinct elongated branches of equal size, each of which develops ordinary leaves. The root is not fusiform. It is very fleshy and stout on the upper part and in the lower portion it is divided into four fleshy branches. The whole structure simulates a human figure.

53. Abnormalities in angiosperms.

K. L. Saksena, Gwalior.

(i) Three abnormal specimens, each having a set of two disc flowers, have been collected from a capitulum of a Sunflower plant. They show different stages of union between ovaries and petals :—

(*a*) One specimen shows partial fusion of the two ovaries belonging to two disc flowers.

(*b*) Another specimen shows complete fusion of the two ovaries, but partial fusion of the two petals belonging to two disc flowers.

(*c*) The third specimen shows complete fusion of the two ovaries and the two petals belonging to two disc flowers.

(ii) Two fruits of *Mangifera indica* are fused together.

(iii) Two fruits of *Solanum Melongena* have fused together.

(iv) The stem of Jasminum is modified into a ribbon-like structure which may be called a phylloclade.

54. Leaf-variation and ascidium formation in *Tabernaemontana coronaria* R.

L. N. RAO, Bangalore.

The paper deals with the chief forms of leaf-variations in *T. coronaria*, such as (*a*) forking from the tip, (*b*) adnation of the petiole to the axis, (*c*) the terminal leaf, and (*d*) ascidium formation. With a brief reference to the previous work on the subject, the above variations are described. The special features mentioned are: (1) In cases of forking, the common petiole contains double vascular strands in the place of the usual solitary bundle. (2) The terminal leaf is solitary and is very much bigger than the biggest normal leaf. (3) The ascidium formation in *T. coronaria* is not very common and, when present, is of epiascidium type. The transition from the terminal leaf with a laminar pocket at the base to the fully formed funnel is very gradual and can easily be noticed. The anatomy of the stalk of the funnel is peculiar in differing from that of the petiole and resembling in general, that of the stem, i.e. hollow cylinder of wood enclosing the central strand of pith. Water collects in these funnels or cups which appears to be the cause for the formation of small pores at the base of the cups. The formation of these pores and their structure have been studied and the results have been embodied.

55. Straight-head disease of rice.

JAGJIT SINGH, Lahore.

The rice-heads or panicles become almost sterile and remain erect when mature. Finely divided roots are replaced by coarse and sparingly branched ones. In the present case interesting morphological abnormalities have been found in the floral parts and these have been described in detail. No causal organisms have been found.

56. Notes on Indian Plant Teratology.

T. S. SABNIS, Cawnpore.

Cases of fission are discussed in the following :—

The root of *Raphanus sativus*; stems of *Brassica oleracea* L., var. *caulorapa* and *Andropogon sorghum*; leaves of *Phaseolus radiatus* and *Phaseolus mungo*; fruits of *Hibiscus esculentus, Mangifera indica, Cucumis trigonus* and *Papaya carica.* The probable cause of the phenomenon in each case has been noted.

Fasciation in stems of *Brassica juncea* var. *Oleifera, Crotalaria juncea, Carthamus tinctorius* and *Dalbergia sisoo* and in the fruit of *Solanum melongena* have been described and tentative explanation offered in each case.

The following abnormalities have been discussed as fully as material permitted: Proliferation in Roses; positive 'dedoublement' in *Artabotrys odoratissimus*; abnormal vegetative growths in the fruit of *Carica papaya*; and Heterogamy, suppression and branching in *Zea mays.*

57. The rôle of the nucleolus in *Hibiscus mutabilis* Linn.

G. P. MAZUMDAR *and* R. M. DATTA, Calcutta.

In this paper the authors deal with the behaviour and rôle of the nucleolus in the microspore-mother-cells of *Hibiscus mutabilis* Linn. In this connection the recent literature on the biology of the nucleolus is reviewed and discussed.

58. The development of pollen in *Victoria regia.*

R. M. Datta, Calcutta.

A detailed description of the cytology and karyology of *Victoria regia* from the meiotic prophase to the formation of the microspores is given. Ten (10) bivalent chromosomes have been counted in polar views at metaphase and Langlet and Söderberg's observations corroborated. Of the interesting stages noted, the connection of the nucleolus with the spireme, the second contraction and the diffuse stages are important. There is strong evidence favouring the telosynaptic interpretation of chromosome pairing. Cytokinesis takes place by furrowing. The presence of a slimy mass without nuclei between the pollen grains is noted and Tischler's observations refuting the occurrence of periplasmodium in the mature anther sacs of *Nymphœa alba* and *Nuphar luteum* by Lubimenko and Maige (1907) corroborated.

59. Studies on the cytology of *Nymphœa sulphurea.*

R. M. Datta, Calcutta.

In this paper the author deals with the detailed description of the cytology of the pollen development of *Nymphœa sulphurea.* The haploid chromosomes are 24 in number. Here also the diffuse stage is noted and cytokinesis takes place by furrowing. Some observations on the cytology of *Nymphœa rubra, N. stellata,* and *N. lotus* (the glabrous leaved variety) are recorded and compared. The material of *N. sulphurea* was obtained from Dr. K. Bagchee of the Forest Research Institute, Dehra Dun.

60. Mitosis in *Allium sativum.*

T. S. Raghavan, Chitambaram.

The somatic chromosome number is sixteen. The prophase spiremes, both the chromomeric and smooth, are double. The chromonematic structure of the chromosomes appears to be evident. The anaphasic chromosomes also seem to be double being composed of two parallel chromonemata. Metaphasic chromosomes are prominently double composed of two chromonemata closely intertwined. Quadruple structure was not observed. The splitting must have taken place only during the prophase. How far the anaphase chromosomes can be regarded as double is discussed. The so-called two chromonemata of the anaphase chromosomes may merely represent the two edges of a cylindrical rod in which form the chromosomes are most likely to be in both the meta- and anaphases. The behaviour of the nucleolus both during mitosis and during cell differentiation is recorded and its probable rôle inferred.

61. Development of the female gametophyte in *Mollugo nudicaulis* Lamk.

H. R. Bhargava, Agra.

The hypodermal archesporial cell divides by a periclinal wall to form an outer primary wall cell and an inner megaspore mother cell. Two and three megaspore mother cells also occur frequently in the same nucellus. The megaspore mother cell increases considerably in size before meiosis. A normal linear tetrad of four megaspores is formed of which the lowest functions and the upper three degenerate. The mature embryo-sac is of the usual eight-nucleate type. The two polar nuclei fuse in the middle of the embryo-sac. There are three antipodal cells.

There are two integuments. The micropyle is very narrow and the ovule is anatropous.

62. The development of the female organ and the embryology of *Balanophora dioica* R. Br.

T. Ekambaram *and* Rama Rao Panje, Madras.

The paper deals with some of the points in which *Balanophora dioica* differs in its life-history from the other species as described by previous investigators. *B. dioica* is peculiar in that a normal reduction division occurs in the megaspore-mother-cell with spindles across one another in the second division. Of the four megaspores, the basal three are smaller in size and rapidly degenerate. The haploid number of chromosomes, both in the mega- and microspore mother cells, is 15–20. Germinated and emptied pollen-grains on the nucellar beak and traces of the pollen-tube in the proximity of the egg-apparatus together with the subsequent behaviour of the egg strongly suggest the occurrence of fertilization. At the time of differentiation of the sex-apparatus, the four antipodal nuclei fuse together into a single, persistent but apparently functionless nucleus. The first two divisions of the egg are longitudinal and the third periclinal. No suspensor is formed; the entire egg enters into the formation of the embryo. The most fully formed embryo consists of 12 cells and is roughly four-sided in cross-section.

Further observations on very young stages now suggest that the female organ corresponds to the nucellus as interpreted by Treub. No integument or micropylar canal is present. Our previous observations on this point seem to be erroneous.

63. Distribution of mechanical tissue in the stem of an aquatic graminaceous species.

G. P. Mazumdar, Calcutta.

The type of distribution noticed here has not been described by Haberlandt in his Physiologische Pflanzenanatomie for cylindrical organs. In its construction instead of the girder principle the principle governing the construction of suspension bridges has been followed. Its function appears to be two-fold: one to resist the lateral compression and the other to stop further progress of cortical and medullary air cavities. Microchemical tests show that the wall of its cells is not highly lignified.

64. Anatomy of the flowers of *Stellera Chamæjasmæ* Linn. (Thymelæaceæ).

A. C. Joshi, Benares.

The pedicel receives a single bundle from the inflorescence axis. This forms a complete cylindrical stele only in the receptacle of the flower. Throughout the length of the pedicel there is a single curved collateral vascular bundle and its structure is completely dorsiventral. The significance of such dorsiventral construction of the axial organs in angiosperms is discussed and it is pointed out that this is to be regarded as a derived and recent condition.

The pedicel, the gynophore, wall of the ovary and the perianth-tube are all full of air spaces. Such an excessive development of the lacunar tissue in a desert plant is explained as due to too much protection from transpiration.

The perianth-tube receives 10 traces. The disk-scale receives its vascular supply from the perianth traces and from its relation with the perianth traces and the stamens, it is to be interpreted as a part of a much reduced corolla. The stamens are in two whorls and receive their vascular supply from the perianth.

At the base of the gynæcium there are four bundles, two large and two small, alternating with each other. The larger bundles supply the ovule. After this each of these forms two bundles, so that at the top of the ovary there are six bundles. Stigma is bilobed and the whole gynæcium is to be interpreted as bicarpellary and not monocarpellary as is mostly done by the taxonomists at the present time.

The affinities of the family Thymelæaceæ with the Nyctaginaceæ as pointed out by Hutchinson are disproved. On the other hand, the demonstration of the disk-scale to represent a part of the corolla, shows that the family must have come from ancestors with two distinct whorls of perianth.

65. Seedling anatomy of two Ficoideæ.

V. SITARAMA RAO, Benares.

In *Trianthema monogyna*, the primary root is diarch, and the root-stem transition is of the type 'a' of Eames and Macdaniels—the phloem groups retaining their position and being directly continuous with the phloem of the stem; each xylem strand forking radially, with the branches swinging through 180° in opposite directions, thus giving two endarch, collateral bundles. These two give rise by division to two arcs of vascular bundles, with five bundles in each arc. The end bundles of each arc pass into the cotyledons on their side, each of which thus receives two bundles. There is a distinct cotyledonary sheath formed by the fusion of the bases of the cotyledons. Each epicotyledonary leaf receives three bundles. The structure of the cotyledon is dorsiventral. There is distinction into palisade and spongy mesophyll and the palisade is two-layered.

In *Gisekia pharnaceoides*, the epicotyledonary leaves receive only a single bundle. In the cotyledon, the midrib bundle and its branches are surrounded by distinct parenchymatous sheaths. In its proximal part palisade-like cells are found on the lower surface also, but are separated from the epidermis by large parenchymatous cells. There is no specially defined spongy parenchyma. The cotyledons have axillary buds.

66. A study of the vascular supply to the foliar organs in the genus Galium and some other members of Rubiaceæ with particular reference to stipule morphology.

P. N. SURI, Lahore.

The writer has studied the vascular supply to the foliar organs in *Galium aparine* Wall, *G. acutum* Edgew., *G. asperifolium* Wall., *G. rotundifolium* L., *Rubia cordifolia* Linn., *Hamelia patens* Jacq., *Coffea bengalensis* Roxb., and *Gardenia florida* Linn.

In the genus *Galium* there are usually 4 or 6 foliar organs of similar nature at each node but the number may be anything between 2 and 9. Only two out of these possess a bud in their axil and are therefore apparently of the nature of leaves while the others are regarded as stipules. Vascular anatomy confirms this point. The two foliar organs with a bud in their axil receive the vascular supply directly from the stem stele where they leave a gap while the others receive branches from these latter leaf traces and have no direct connection with the stem stele.

The same is true of *Rubia cordifolia* Linn., which like *Galium* has 4 similar foliar organs at each node. Unlike *Galium* and *Rubia*, in *Hamelia patens* Jacq. and *Coffea bengalensis* Roxb. the leaves are large and the stipules interpetiolar. The arrangement of the vascular system, however, is same, although the amount of tissue to the stipules is smaller in these latter cases.

Gardenia florida Linn., however, presents a different aspect. The stipules which are interpetiolar, receive their vascular supply direct from the stem stele and leave a gap in much the same way as the true leaves.

67. Pollination of a Bignoniaceous tree by bats.

T. C. N. Singh, Sabour.

The author, after careful observations, has found that the pollination of a Bignoniaceous tree—*Oroxylon* sp.—is effected under the cover of night (betwen 8 P.M. to 3 A.M.) by two species of bats. The opening of flower buds coincides with the visits of these pollinators and by the next morning the fleshy corolla-tube of all such visited flowers are shed. Details about the mechanism of pollination are described.

68. A cheap device for using safety razor blades for microtome sections.

P. Maheshwari, Agra.

To sharpen a microtome knife requires considerable skill and labour, and it is the dull knife which causes most of the trouble in cutting as experienced by beginners. A safety razor blade obviates this difficulty and due to the low price the blades can be changed from time to time. A blade-holder is not absolutely necessary. The author recommends melting some hard paraffin (about 60° melting point) on an old knife blade with a plane surface. A clean safety razor blade can be slipped on to it in the middle and the knife plunged at once in cold water. As the paraffin solidifies, the blade sticks fast to the knife. Care should, however, be taken that the edge of the blade does not project too far, as in that case there will be less rigidity and it will be impossible to get good sections. The above method has been successfully tried by students in this laboratory for more than two years.

69. A note on the pneumatophores of *Coix lachryma-Jobi* L.

J. F. R. d'Almeida, Bombay.

This grass commonly thrives in the rains. It may grow in well-drained soil or in water-logged soil or even partially submerged in water. In the latter two cases it bears pneumatophores (upwardly directed branches of the prop-roots). It is doubtful whether the upward growth of these pneumatophores is due to negative geotropism or to aerotropism. The pneumatophores are for the first time described here. Their structure is compared with that of the ordinary roots of the plants whether growing as a land plant or in water and the differences observed are seen to be correlated to their respective functions.

70. A note on the aerenchyma of *Sesbania aculeata* Poir.

J. F. R. d'Almeida, Bombay.

Sesbania aculeata Poir. is a marsh herb which also thrives well as a land plant. It has been known to give off adventitious roots covered with spongy aerenchyma from the submerged portion of the stem when the plant grows in water. The aerenchyma has been described by Scott and Wager and the roots have been regarded by them to be swimming roots. Goebel, on the other hand, considers them to be breathing organs. Both views are partly correct. The roots serve as balancing floats and help the plant to maintain its equilibrium in water; at the same time the aerenchyma developed in these roots obviously forms part of the breathing system of the plant and indirectly, at least, facilitates respiration. But the part chiefly concerned with respiration is the aerenchyma developed on the submerged portion of the stem when the plant grows in water. This aerenchyma of the stem is for the first time mentioned and described here. It is of the nature of a periderm, being developed from an extra-endodermal phellogen, and like the type of aerenchyma described by Schenk in the case of Jussiuæa and other plants shows a radial and concentric arrangement of its component cells. It should be noted however that this arrangement is not recognized by Scott and Wager in the case of the aerenchyma of the roots of *S. aculeata.*

71. On the behaviour of the tubers of *Eleocharis plantaginea* R. Br.

J. F. R. D'ALMEIDA, Bombay.

This sedge is pretty common along the borders of tanks. The plant consists of green phylloclade-like stems (modified inflorescence-axes) springing in tufts from an underground portion. Several stout, spongy roots spread out horizontally in all directions from the underground portion. In addition to roots the underground parts also bear a number of white underground branches (stolons), the terminal portions of which expand into tubers. Facts regarding the behaviour of these tubers are recorded, the conditions for their germination elucidated, and the causes of their dormancy in certain cases explained.

72. A note on the structure and functions of the diaphragms occurring in the assimilating shoots of *Eleocharis plantaginea* R. Br.

J. F. R. D'ALMEIDA, Bombay.

The anatomy of the assimilating shoots of this marsh-sedge shows no apparent difference in structure between the immersed and the aerial parts. The hollow construction of the shoot is determined rather by mechanical considerations than by the need of aeration occasioned by the life in water. Incidentally, however, the presence of air-spaces enables the plant to take readily to water. The stem is traversed by longitudinal air-spaces, there being an axile air-cavity due to the disintegration of the central mass of ground tissue and a circle of smaller, radially arranged air-spaces outside this. All the air-spaces are traversed by numerous transverse diaphragms which differ in some respects from the diaphragms described in the case of other plants. The diaphragms of *Eleocharis plantaginea* differ amongst themselves. Most of them are thin and membranous (minor diaphragms) but interspersed at regular intervals along the length of the shoots are stouter, more rigid diaphragms (major diaphragms). The latter stand out prominently and make the stem appear transversely septate from outside when dry. The structure of these two types of diaphragms is described in detail. The functions are seen to be the same as those mentioned for the diaphragms of other plants by previous writers. It is shown how the differential constitution of the two types mentioned above together with the new features observed helps more effectively in the performance of these functions.

73. On the development of secondary aerating tissues in the stem of *Sphenoclea zeylanica* Gaertn.

J. F. R. D'ALMEIDA, Bombay.

The adaptations of this marsh plant, including the massive aerenchyma which is its most conspicuous feature, have so far escaped the attention of botanists. The structure of the stem especially with reference to the primary lacunar system is first dealt with and the development of the secondary (non-vascular) tissues traced. As a result of submergence there is a development of aerenchyma similar to that recorded by Schenk and others in the case of *Jussiuœa* and other plants. This aerenchyma falls under the definition of periderm and is produced by a phellogen which arises outside the pericyclic groups of bast fibres. The aerenchyma of *Sphenoclea* differs from the type previously described by Schenk and others in that there is no concentric arrangement of cells (viz. rings of rounded cells separated by elongated supportive cells). This aerenchyma is not the only secondary tissue formed. Additions are also made to it from without. The loose tissue formed outside the pericyclic groups of bast fibres is therefore not entirely an aerenchyma in the strict sense of the word applied by Schenk. Side by side with the formation of aerenchyma there may be formed a considerable mass of secondary tissue between the aerenchyma-forming phellogen and the bast fibres, and between the latter and the soft bast.

74. Embryo-sac and the development of the endospermal haustorium in *Alonsoa sp.*

C. V. Krishna, Mysore.

The anatropus ovules are arranged on the thick axile placenta and the peculiar orientation of the ovules is due to the long funicles present. Massive integument and reduced nucellus have been met with in this plant also. Tapetum of integumentary origin surrounds the embryo sac, and this layer is composed of small cells far from conspicuous. The first two transverse divisions of the fusion nucleus result in a row of three cells, of which the middle one by a series of divisions gives rise to the endosperm. The micropylar cell by two longitudinal divisions gives rise to four uninucleate branching vermiform haustoria which find their way into the tissue of the integument. The chalazal cell by a longitudinal division develops into two uninucleate haustoria which are far from aggressive and which at a later stage, just before the disintegration of their nuclei, present a binucleate appearance by the dissolution of the separating membrane. The development of the embryo is of the typical dicotyledonous type.

PALÆOBOTANY.

75. Notes on the anatomy of some silicified ferns from the Cretaceous of Germany.

A. R. Rao, Lucknow.

From a recent tour of Europe, Prof. Sahni brought with him on loan the type-specimens of some Cretaceous ferns preserved at the Museums in Berlin, Dresden, and Breslau. These specimens had already been described by several of the well-known older authors, e.g. Corda, Cotta, Goeppert, Renault, and Stenzel. But at Prof. Sahni's suggestion the author undertook a re-examination of the material, with the result that the following new points have been brought to light :—

Protopteris Cottai Corda, from Grossenhain in Saxony: The basal loop of the leaf-trace is not simple as previously described, but plicate. This fact strengthens the cyatheoid affinities of the plant, already suspected on other grounds. The layer called by Corda 'innere Bastscheide' occurs on both sides of the stele in a position corresponding to that of a pericycle, and is here interpreted as such. An explanation is offered of the way in which the large number of roots found their way into the pith.

Caulopteris Brownii Ren. The presence of a definite endodermis showing Casparian strips is demonstrated; the mode of formation of the leaf-trace is elucidated.

Rhizodendron oppoliense Goeppert and *Protopteris fibrosa* Stenzel, both from the Cretaceous of Oppeln in Silesia. A close comparison of the type-specimens, including a number of new sections made at Lucknow, indicates that these two species agree very closely with each other except for a few differences, the most important being the nature of the leaf trace. Most of the details of stelar anatomy are identical. In both cases the same kind of cells compose the pith, with its scattered fibrous bundles. In the type-specimen of *P. fibrosa* a definite endodermis with Casparian strips has been detected and Gothan describes a similar layer in a large specimen of *R. oppoliense*, fragments of which the author has also examined. In *P. fibrosa* there is no outer zone of adventitious roots, nor is there any sign of the cortical sheath of sclerenchyma, both of which are present in Goeppert's species.

All the above ferns seem to be allied to the modern Cyatheaceæ with which they show obvious structural analogies, both in the form of the leaf-trace and in the stelar structure.

76. The silicified flora of the Deccan Intertrappean Series. Part I. General.

B. SAHNI, Lucknow.

This is the first of a series of papers describing the flora of these freshwater beds, which are interstratified with lava flows and are exposed in numerous small patches scattered over an enormous area in the peninsula. The beds are generally regarded (on indirect evidence) as Upper Cretaceous, but a detailed investigation of the flora may possibly support the old view that they are Tertiary.* Dr. Fermor, Director of Geological Survey of India, considers that the Intertrappean beds in the Nagpur-Chhindwara region belong to the lowest portion of the series, which in this part of the country is frequently seen resting unconformably upon the Archæan rocks.

The plants are all silicified and often beautifully preserved. It has been possible to stain them vividly with Gentian Violet; stained sections will be exhibited. The material in hand includes the old Hislop and Hunter collection, lent by the British Museum; petrified palm stems and dicotyledons from the Nerbuda and Upper Godaveri basins (Nagpur Museum, Geological Survey and the author's own collection); some fossiliferous cherts from the Sausar District, C.P., lent by the Geological Survey (Crookshank collection); and numerous cherts collected in January, 1926, by the author in the same region. In 1930, Prof. Rode of Benares found at Mohgaon Kalan, east of Chhindwara, some palm woods and a few fruits like some discovered long ago by Hislop, Hunter, and Viraswamy; similar fruits and also a few new types were collected in January, 1931, at Rode's locality by Prof. Parija and the author; a few specimens of stems and roots from the same place were later contributed by Prof. Agharkar.

The Sausar cherts are no doubt silicified muds of lacustrine or fluviatile origin. They contain a flora including several unmistakable aquatic forms: Characeous fruits, angiosperm stems with large air channels and poorly developed steles, fragments of ærenchymatous tissue, algal filaments covered with unicellular epiphytes; especially common is an *Azolla* whose mega- and microsporocarps, including the glochidia, are perfectly preserved. In addition there are fragments of tissue in various stages of decay, fungal mycelia, many types of well-preserved spores, and seeds representing several new genera.

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* See postscript on page 319.

A new type of ovuliferous cones of Conifers, preserved in a fine volcanic ash from Takli near Nagpur, was recently described as *Takliostrobus alatus* (*Sahni, 1931, Palæontologia Indica, N.S., Vol. XI*); another, presumably also from the Deccan Intertrappean Series, was named *Indostrobus bifidolepis*. Among several new species of silicified palm stems recently described (*Proc. U.P. Acad. Sci., Lucknow, Dec. 1931, pp. 140–144*) were at least two (*P. sundaram, P. Edwardsi*) from the same formation, and several others are now being described in a monograph to be published by the Geological Survey. Three new species (*P. Hislopi, P. kamalam, P. Sahnii*) have recently been described by Rode from Mohgaon Kalan (*Quart. Journ. Geol. Min. Met. Soc., India, Vol. V*).

77. The silicified flora of the Deccan Intertrappean Series. Part II. Gymnospermous and Angiospermous fruits.

B. Sahni, Lucknow.

The fossils here dealt with belong to two collections: (1) the Hislop and Hunter Collection, and (2) some fossils collected in 1931 by Prof. Parija and the author at Mohgaon Kalan, east of Chhindwara (*see Part I*). The following is a provisional list:—

A. *Gymnosperms.*

1. *Takliostrobus alatus* Sahni from Takli (*Palæont. Indica, N.S., XI, pl. XV, fig. 104, 1931*).
2. ? *Pityostrobus crassitesta* Sahni (cf. *loc. cit., figs. 105, 106*).

B. *Dicotyledons.*

3. *Enigmocarpon Parijai* gen. et sp. nov. Several elliptical fruits with a thick pericarp, containing numerous crowded seeds of peculiar structure. Preserved in a black chert from Mohgaon Kalan. Coll. Sahni, January, 1931.
4. A single specimen of a presumably dicotyledonous fruit, exposed in a rough transverse section on the weathered surface of a chert from Mohgaon Kalan. Three loculi are preserved out of a probable five. Coll. Sahni, January, 1931.

C. *Monocotyledons.*

5. *Amomocarpum sulcatum* sp. nov. A triangular fruit, marked with longitudinal ridges, and apparently derived from an inferior ovary; the perianth scar is preserved at one end. A second specimen, broken across, shows a few large seeds with a characteristic rugose surface. Hislop and Hunter Collection (Locality unknown).
6. *Palmocarpon* (*Iriartites*) *takliensis* sp. nov. Several specimens of ovoid fruits; the epicarp shows numerous very fine ribs radiating from an apical umbo. Hislop and Hunter Collection (British Museum), from Takli.
7. *Palmocarpon bracteatum* sp. nov. A single specimen of a subspherical fruit, attached on an axis bearing short thick, broadly rounded longitudinally ribbed bracts. Hislop and Hunter Collection (British Museum).
8. *Palmocarpon trigonum* (Rode). Fruit obovoid, the broader distal end prolonged into an acuminate, beak-like process; cross-section of fruit triangular with the angles well rounded; fruit wall thick, traversed by radial septa of hard tissue. Loculi three, each containing a large ellipsoid seed. Hislop and Hunter Collection, British Museum (locality unknown) and Sahni Collection (Mohgaon Kalan).

9. *Palmocarpon* spp. Distorted fruits, probably of palms. Hislop and Hunter Collection.
10. *Viracarpon hexaspermum* gen. et sp. nov. A very peculiar type of fructification, having 6-seeded fruits closely arranged on an elongated axis; probably this is the fruit which Hislop compared to a mulberry (cf. *Carter's Geol. Papers on West. India, p. 711, 1857).*

78. The silicified flora of the Deccan Intertrappean Series. Part III. *Sausarospermum Fermori* gen. et sp. nov.

B. Sahni *and* B. P. Srivastava, Lucknow.

The seeds here referred to the new genus *Sausarospermum*, about 20 in number, were all found in a single block of chert collected by one of us in 1926 at Sausar.

Seed radiospermic, about 2·3 by 1·4 mm., elliptical, longitudinally ribbed. The number of ridges at the two extremities is twelve, over the body of the seed about twenty-four. Integument three-layered, expanded at the base. Micropyle about 0·2 mm. wide. The nucellus is completely fused to the integument, except in the micropylar region; here it consists of a dark mass of tissue, possibly representing a crushed pollen chamber. Immediately beneath this, but within the nucellus, a characteristic dark-coloured disc is constantly present. Megaspore membrane thick and definite. No trace of a vascular supply is seen anywhere in the seed. In some longitudinal sections, portions of the embryo-sac are seen filled with a tortuous body, possibly comparable to the suspensor of Gymnospermous embryos. There is a possibility that the seed was stalked. A poorly preserved axis is seen lying obliquely in contact with the chalazal end of one seed. An organic continuity of the tissues of this axis and of the seed is not traceable, but the appearance of the axis suggests that it was longitudinally ribbed, like the seed itself.

These characters taken together mark out the seeds as belonging to a hitherto unknown type. The affinities are quite obscure. Resemblances in isolated features are shown with the Caytoniales, Bennettitales, Gnetales, and even the Pteridosperms.

The longitudinal ridges on the integument which are specially prominent in the micropylar region, as well as the peculiar expansion of the integument towards the chalazal end, strike one as antique features, more appropriate to an archaic group like the Pteridosperms. In these features at least there is some resemblance, however superficial, with such ancient types as *Physostoma, Polypterospermum,* and *Polylophospermum.* Can it be that this group persisted so late as the Deccan Trap period, almost till the dawn of the Tertiary era? We hesitate to suggest this, although the researches of Hamshaw Thomas tend to show that plants closely resembling some palæozoic Pteridosperms in the structure of their reproductive organs existed in the Southern Hemisphere as late as the Upper Triassic.

At present it is unfortunately impossible to say whether the seeds belonged to an angiosperm or a gymnosperm. The possibility is not excluded that they represent an entirely new group of plants, related both to the gymnosperms and the angiosperms, and evolved during a period of the earth's history when the angiosperms were rapidly emerging as the dominant group of the vegetable kingdom.

79. The silicified flora of the Deccan Intertrappean Series. Part IV. *Azolla intertrappea* sp. nov.

B. Sahni *and* H. S. Rao, Lucknow.

In the summer of 1925 the Director of Geological Survey of India kindly sent to one of the authors for investigation a few blocks of chert, collected by Mr. H. Crookshank in the Sausar Tahsil, Chhindwara District (Lat. 21° 39′ N., Long. 78° 47′ E.), in the Central Provinces. One of the blocks showed a number of fragmentary plant remains on the weathered surface. Thin sections revealed, among other fossils, a small triangular body of a spongy structure, which was at once recognized as a massula of an *Azolla*. Embedded in the well-preserved sponge-work of the massula were a few darker coloured microspores, while a number of unmistakable glochidia, each terminating in an anchor-like tip, projected from the surface. Two massulæ of the same type were later found in another section cut from the same block. In the hope of finding further material of interest the original locality as well as the surrounding country was searched in January, 1926, with the result that many fossiliferous chert fragments were collected. Two of these blocks showed numerous places where parts of the *Azolla* were preserved : leaves, more or less entire microsporocarps with their groups of spherical microsporangia, and also several megasporocarps were discovered, there being often one or more megasporocarps among a group of microsporangia. All these fragments undoubtedly belong to one and the same species. The form and structure of the megasporocarp is distinct from that of any known species : the ' float ' being specially large and rounded at the apex. It appears to consist of several parts which lie rather low, somewhat like a helmet, over the top of the megaspore. The wall of several megaspores has also been seen covered with a felt of fine threads exactly like those which are found in modern species of the genus and in which the glochidia become anchored. However, in the fossil form no glochidia have so far been discovered attached to the megasporocarps.

The only other species of *Azolla* known to us in the fossil state is *Azolla prisca* described by Mrs. E. M. Reid and Miss M. E. J. Chandler from the Tertiary of the Isle of Wight (*Reid and Chandler, the Bembridge Flora, Brit. Mus. Catalogue, Vol. I, 1926*).

So far as known at present the fossil record of the Hydropterideæ does not extend below the Tertiary ; the present find therefore either indicates a Tertiary* age for the Intertrappean beds, and supports the view of Sir A. Smith Woodward that they may be Eocene, or it extends the range of the Hydropterideæ into the Mesozoic.

* *Postscript.*—Since the above papers were communicated a comprehensive survey of the Intertrappean flora has shown that the affinities of the flora are decidedly Tertiary. The main points are : (*a*) a very marked preponderance of palms, a group which, although it first appeared in the Cretaceous, gained enormously in importance during the Tertiary ; (*b*) the occurrence of *Nipadites*, a genus characteristic of the Eocene, first recorded by Hislop (*see Carter, loc. cit., p. 718*) and recently found again by Rode (*Current Science*, Nov. 1933, p. 171) ; (*c*) the occurrence of *Azolla*. The above facts relate to the flora of the upper Nerbada and Godaveri basins, which must be even younger than that of the regions further south-west. *B.S.*

PHYSIOLOGY AND ECOLOGY.

80. The study of photosynthesis in light differing in intensities of the visible radiations and in monochromatic light.

R. J. MEHTA, Bombay.

Dastur and Samant showed recently that there is great difference between the photosynthetic activity in sunlight and in artificial light of equal intensity and that this was probably due to the difference in intensity of the blue-violet rays in the two lights. Sunlight is more intense in these than artificial light. It was therefore undertaken to study the photosynthetic activity in artificial light from different sources showing differences in the intensities of the different radiations. Photosynthesis was studied in a carbon arc-lamp, Phillip's daylight lamp of 1,500 watts, ordinary electric lamp of 1,500 watts, and incandescent oil lamp of 200 c.p., the intensity of the blue-violet rays in these lights decreasing in the same order. Photosynthesis was determined by estimating the carbohydrate contents of leaves and petioles of plants exposed to these lights after making their intensity equal. The results showed that photosynthesis also decreased in the same order. This clearly shows the importance of the blue-violet region of the visible spectrum in photosynthesis.

In order to be certain, the effect of red, blue, and white lights of the same intensity on photosynthesis was also studied. The results showed the photosynthetic activity to be the highest in white light, medium in red light, and very feeble in the blue-violet. This shows that both the red and blue regions are necessary for normal photosynthesis. It can be concluded from these results that perhaps the photosynthetic process takes place in more than one stage, the first stages going on better in light of longer wavelengths while the later stages require shorter wavelengths for normal action. Hence it is necessary to take into consideration the distribution of energy in the different parts of the full spectrum over and above the total energy supplied to the plants.

81. A study of Hydrogen-ion concentration and the intake of Nitrogen by the rice plants.

V. V. Kalyani, Bombay.

It was undertaken to show that the absorption of ammoniacal nitrogen in the early stages and the nitrate ions in the later stages is correlated to the iso-electric point of the proteins of the protoplasm of the tissues of the rice plant. The changes in the pH value of the soil and the rice plants treated with ammonium sulphate, sodium nitrate and a mixture of the two salts and of untreated rice plants were determined. The pH values of the solutions of the above salts and the rice seedlings kept in the solutions were also determined before and after the seedlings had remained in the solutions for a fixed time. It was also found necessary to determine the iso-electric point of the proteins in the protoplasm of the roots and leaves of the rice seedlings. Throughout the work the electrometric method for determining the Hydrogen-ion concentration was used. Many conclusions can be drawn from the results and a few are as follows.

The results show that the pH value of roots lies on the alkaline side of the iso-electric point of their proteins and therefore the latter will combine more readily with ammoniacal nitrogen, it being in the form of a basic ion in the earlier stages of growth. The reverse is the case during the later stages of growth, the absorption of nitrate nitrogen taking place while that of ammoniacal nitrogen diminishes.

82. The osmotic pressures and H-ion concentrations of sea-weeds in relation to those of sea water.

S. A. Pasha, Bombay.

As the H-ion concentration of sea water is one of the most important factors that determines the distribution of the algal forms, it was undertaken to study the relation between H-ion concentration of sea water and algal forms, and the osmotic pressures of their cells. The H-ion concentration was studied by the indicator method as developed by Clark. The osmotic pressure was determined by the plasmolytic method.

The results indicate that the cell sap of algæ is nearly neutral, the pH value of sea water varying from 8·0 to 8·31 and that of the cell sap from 6·6 to 7·0. The osmotic pressure of the algal forms is always higher than that of the sea water.

83. The suction and osmotic pressures of the Mangroves.

S. A. Pasha, Bombay.

It was put forward by Drable and Drable that the plants living in salt marshes are exposed to different degrees of salinity at different times and that the concentration of the cell-sap varies according to the changes in the external medium. It was therefore undertaken to study the suction pressures of mangroves growing near Bombay at different times of the year. The pressure is highest in leaves, medium in stems, and lowest in roots. There is a marked increase in the suction pressure from August to October.

84. Energy absorbed by leaves from plane-polarized and non-polarized beams of light of equal intensities.

L. K. Gunjikar, Bombay.

It was undertaken to study the energy absorbed by a leaf from normal light and polarized light of equal intensities, as there is a difference of opinion as regards the accelerating action of polarized light on biological phenomena as compared to normal light. An apparatus was devised to measure the coefficient of absorption of light energy by a leaf from plane polarized and non-polarized lights of equal intensities. Four different percentages of polarization were used. Leaves of twelve different species were examined. The results clearly showed that the leaves absorb larger amounts of light energy from polarized light as compared to the light energy absorped from normal light. A correction for the loss of light energy due to reflection from the leaf surface was made. The absorption of greater energy from the polarized radiation may show itself in the acceleration of some processes and not in others according as the energy absorbed is or is not acting as a limiting factor.

85. The effect of elliptically polarized light on the rate of formation of carbohydrates in leaves.

L. K. Gunjikar, Bombay.

It was undertaken to determine the effect of elliptically polarized light on the formation of carbohydrates in leaves. A special apparatus was devised to obtain elliptically polarized light. Plants were exposed to this light and normal light of equal intensities, and the leaves analyzed for reducing sugars, cane sugar, and starch. The results clearly show that the formation of carbohydrates in leaves exposed to normal light is higher than that of the leaves exposed to elliptically polarized light. This indicates a depressing or retarding effect of elliptically polarized light on, at least, the formation of carbohydrates in leaves.

86. Influence of nutrition on sexual expression in Maize.

H. Chaudhuri, Lahore.

The author published a short note on the above subject (*Current Science,* Vol. I). This paper deals with further experiments on the subject.

87. Effect of ultra-violet light on *Colletotrichum gloeosporioides.*

SHER AHMAD, Lahore.

The results taken together indicate that ultra-violet light exercises a stimulatory effect on the development of reproductive structures which increases with the time of exposure until an optimum is reached, after which lethal effects become more pronounced, viz. acervuli formation is stopped and the mycelium is killed.

88. Effect of ultra-violet rays on the germination and growth of seeds of *Cicer arietinum.*

SHER AHMAD, Lahore.

At a distance of 26 cms. from the arc, radiation did not produce any effect on the germination of seeds. Seeds of the white variety showed an increased rate of growth of their hypocotyles on irradiation in the dry condition. No such difference of growth in rayed and control seeds was seen in the black variety; seeds of the white variety also failed to show any such difference when exposed after soaking. It is concluded that black colour and also soaking in water probably mask the effect of ultra-violet light.

89. Studies in the tropic curvature of certain angiospermous flowers—II.

P. PARIJA *and* T. C. N. SINGH, Cuttack.

This year the work has been extended to the study of the flowers of Lady's-finger and two Amaryllids. In each case geotropism alone appears to be the controlling factor. In *Hibiscus esculentus,* however, the straightening up of the flower-pedicel at a late stage, is purely a post-fertilization phenomenon. It is interesting to note that the castrated flowers of *Eucharis* sp. do not show the characteristic diageotrophic curvature. So it is apparent that the primary stimulus is perceived by the andrœcium and is then transmitted to the perianth-tube. Further work is in progress.

90. The influence of various carbohydrates on the growth of certain *Fusaria.*

A. K. MITRA, Allahabad.

Three *Fusaria* were studied in relation to their growth on nine carbohydrates. It was found that a particular carbohydrate did not exert the same influence on all the three species. Lactose proved to be least favourable for the growth of *F. semitectum* and *F. camptoceras* but *F. viride* showed a fair development on it. Glycogen proved to be a little more favourable for the growth of all the three species than starch. Generally a very good development of almost all the characters was found on sucrose which proved to be more favourable than glucose. Other sugars, such as maltose, galactose, mannose, fructose, etc. occupied different positions in the series showing their suitability for the growth of the different species.

91. The influence of mechanical stimulus on respiration in starving leaves of *Aralia.*

A. B. SARAN, Sabour.

The effect of wounding on respiratory activity of the starving leaves of *Aralia* was studied with a view to ascertain whether the respirable material present in the leaves at the time of wounding has any relation to the enhanced CO_2 output following wounding. The results of numerous experiments go to show that as the period of starvation increases from 2·5 hours to 72 hours the after-effect of wounding goes on decreasing. But at 96 hours of starvation there is a secondary rise in this after-effect. The sugar-injected leaves show a higher after-effect than that of the control, although both were starved to the same extent.

92. On the influence of dissolved CO_2 gas in culture media on the development of seedlings.

A. B. Saran, Sabour.

With an idea of studying the development of seedlings in relation to dissolved CO_2 gas in the culture medium, some preliminary experiments with gram seedlings were conducted and it has been observed that during the earlier stages in the development of gram seedlings carbonic acid, if available to the roots, imparts a beneficial effect on the growth of the seedlings.

93. Investigations on the presence and disappearance of starch in leaves.

B. N. Mukherji, Calcutta.

Leaves of plants including 10 trees, 8 shrubs, and 30 herbs were examined for the presence of starch at different parts of the day and of the year. Starch was found to be present in all of them which included some Monocotyledons.

In general starch was not found to disappear completely during the night. In some of the plants the amount of starch remained the same (as seen by iodine test) during day and night, whereas in others it diminished at night and this was more pronounced in winter when in a few cases complete disappearance was noticed.

Experiments on the effect of different degrees of humidity were performed with 19 plants; and it was found that drier condition favours the disappearance of starch from leaves.

The effects of high and low temperatures were studied and the experiments showed that high temperature favours disappearance of starch from leaves while low temperature does not.

Quantitative estimation of the variation of starch content of leaves under natural conditions is in progress.

The details are embodied in the paper.

94. On the osmotic pressure relations of our plants.

J. Sen Gupta, Calcutta.

The author is engaged in a study of the osmotic pressure relations of the different groups of Bengal plants under natural conditions using the cryoscopic method with press-saps of leaves.

The collection of the material, obtaining the press-sap, as also the determination of the freezing point depression, were done according to the modified method of Walter (the simple press and the micro-cryoscope after Drucker-Burian were used) employed in his extensive investigations of the problem in Europe and America. The calculations of the osmotic values were done according to Harris and Gortner.

This is a preliminary report containing readings for about 30 common plants from the college garden. The values obtained were different in the different species and some variations in the same species recorded. The osmotic pressure in the species examined up to now is seen to lie between 7·2 Atm., and 16·1 Atmospheres.

Further details are to be seen in the paper.

95. On the opening and closing movements of the leaves and flowers of *Portulaca quadrifida*.

S. GHOSE, Lahore.

The author was attracted by the opening and closing movements exhibited by the leaves and flowers of *Portulaca quadrifida,* a common succulent herb.

On closer observation from a number of small pots prepared for the experiments the opening and closing time in shade were found to be—

	Opening.	Closing.
Leaves ...	7-45 A.M.	4-48 P.M.
Flower	11-40 A.M.	2-21 P.M.

(an average of 88 readings). In the sun they take place half an hour earlier.

Experiments on the effect of light showed that if the pots were kept in the dark room or a dark box in the laboratory, the leaves and flowers remained closed. Experiments on the effect of longer darkness hours and shorter light hours showed that by prolonging the darkness during the early parts of the day, the opening and closing time of the flower could be shifted to about 1-30 and 4-30 P.M. respectively. But in some experiments where the pots were kept in darkness devised under the sun's rays on the roof the flowers were seen to open at about 1 P.M. for an hour though the leaves remained closed.

Experiments on the effect of different temperatures are in progress.

96. Action on photographic plates by the green portions of plants.

T. C. N. SINGH, Sabour.

Photographic plates, kept with their film-side in contact with green leaves of various species of plants in a dark-box in the dark-room, have on developing been found to have been affected in such a manner that even the minutest details of the veins and outline of the leaf can well be seen on the developed negative. The length of time which produces the desired action differs in different species. Interesting experiments other than these, with chlorophyll extract of plants, have been tried with equally successful results. Details of the experiments are described in the fuller paper.

97. On the capacity of *Riccia himalayensis* St. for resisting drought.

P. PARIJA, Cuttack.

A number of thalli of *Riccia himalayensis* St. growing in a pot were kept under observation for about two months. Frequent determinations of moisture content of the soil and the survival of the apparently dry thalli were made. It was found that when the moisture content of the subsoil (depth 1 inch) falls below 2·6% the plants fail to revive when transferred to wet soil.

98. Dominant flower colour in the Alpine Himalayas and Tibet.

S. R. KASHYAP, Lahore.

During last summer the writer paid a visit to Rupshu passing through the Rohtang Pass and the Baralacha Pass, both going and coming. His conclusion expressed some time ago that the yellow colour is the most dominant in the Alpine Himalayas and Tibet has been strongly confirmed. In June whereas *Anemone rivularis* with its white flowers was exceedingly conspicuous at the base of the Rohtang Pass (13,000 ft.), it was replaced by the yellow flowered *Anemone polyanthes* near the top of the pass which was entirely covered with snow for some miles. The only plants met with here and there at the top were *Trollius acaulis* with its bright yellow flowers and the minute *Oxygraphis polypetala* also with yellow flowers. On the way back in August yellow flower plants were far more numerous and conspicuous at the top of the pass with a sprinkling of blue and other colours here and there. Among the yellow flowered plants at the top the commonest were *Ranunculus hirtellus*, *Geum elatum*, *Potentilla argyrophylla*, *Anemone polyanthes*, and a few more, whereas the blue was represented by patches of *Lagotis glauca*. At lower levels *Potentilla argyrophylla* had only bright red flowers and a little higher up one could find all shades of orange, between red and yellow, and red flowers were practically altogether absent near the top. Similarly on the Baralacha Pass, 16,000 ft., yellow was the dominant colour. In Rupshu, 15,000 ft. and upwards, the only conspicuous plant for miles together was *Caragana pygmæa* with its yellow flowers. In some places *Thylacospermum rupifragrum* is met with, with its minute yellowish flowers and only occasionally *Arenaria musciformis* shows its conspicuous white flowered tufts. Other plants are very few and generally inconspicuous.

99. An ecologic and systematic study of the ferns of Mussoorie.

P. N. MEHRA, Lahore.

The present paper describes a systematic and ecologic study of the ferns of Mussoorie. The area studied extends from Dehra Dun, 3,000 ft., above the sea, through Mussoorie about 7,000 ft., and along the Mussoorie-Tehri Road up to an altitude of 8,500 ft.

The collections were made during the two principal rainy months July and August of the year 1932, when the vegetation is at its best. Altogether 73 species are met with in that area. A new variety *Pleopeltis simplex* var. *Kashyapii* is very common as an epiphyte along the Tehri road. *Goniophlebium microrhizoma* Clarke and the closely allied *G. lachnopus* Wall. undergo extreme modifications in size and texture of the fronds according to the ecologic habitats where they grow. Ecologically the ferns have been grouped into different units depending upon the nature of the habitat they occupy.

100. Notes on the flora of Kiangtsu Plain Rupshu, 15,000 ft.

S. R. KASHYAP, Lahore.

This plain is situated at an altitude of 15,000 ft. above the sea and about 5 miles long and about a mile broad, leading to other similar plains on both sides. The level of the plain varies by a few feet in different places and it is interesting to note that correspondingly the plant associations also become changed. These changes are apparently dependent upon the amount of moisture available. There would be more moisture at lower levels even if the difference is only a few feet. At one place one meets with almost a pure association of *Caragana pygmæa*. A little further on it is replaced by an almost pure association of *Thylacospermum rupifragrum*. This species forms very dense cushions which are sometimes perfectly flat and almost flush with the surface of the soil and in other places they are dome-shaped as much as a foot high. This difference in shape depends on the amount of erosion going on at the particular place. If one knew the rate of growth of the plant it would be quite easy to calculate the rate of erosion at the place. Still further we have cushions of *Arenaria musciformis* to the exclusion of the other two. Gradually this becomes associated with *Eurotia ceratoides* and by and by a number of other plants, especially tufts of grass. A list of the other plants which are not so conspicuous and not so numerous is also given in the paper.

101. The action of spreaders on the effective killing of spiked sandal plants.

A. V. VARADARAJA IYENGAR, Bangalore.

It was pointed out in an earlier communication (*Proc. Indian Sci. Cong.*, 1933, *Patna*) that 'Atlas' was effective in killing spiked sandal plants. In the course of the year, a cheap and successful substitute for the patented 'Atlas' was evolved. This is found to be very useful in killing the diseased trees in about a fortnight's time and in a few cases, a second application has ensured complete death of the plants. A further improvement was effected in this preparation by the employment of spreaders like some proteins, saponins, etc. Tests have been made of these products on large scale operations with enormous success.

102. Significance of grafting experiments in relation to the natural incidence and spread of spike disease.

M. SREENIVASAYA *and* S. RANGASWAMI, Bangalore.

Grafting of sandal trees, under sylvicultural conditions, has revealed interesting information regarding the dosage of infective material that would be necessary to infect the plant. One set of results, conducted in North Salem, showed that the incubation period, with a given dose of infective material, is independent of the girth class and that about 80 milligrams of infective tissue is sufficient to spike a tree weighing about four hundredweights in the green condition. The eighty milligrams is a quantity which can be carried by certain insects individually or collectively by a swarm. This observation lends support to the theory of insect transmission and to a certain extent explains the long distance flights of disease which occur under natural conditions.

The grafting experiments in the nursery and in the forest, which were conducted at different seasons of the year, show that season plays a very important rôle in effecting transmission. The sandal plants, under a given environment, are comparatively more susceptible to infection during the months of April, May, June, and July. These months therefore constitute the most vulnerable period for the sandal plants. The practical significance of these observations in the effective control of spike is discussed.

103. A new method of finding out the water-content and water-capacity and the air-content and air-capacity of soil.

F. R. BHARUCHA, Bombay.

This new method by M. Siegrist is a modification of the one by Raman and Burger. It is simpler to work with and has proved of great use to agriculturists and foresters.

After explaining the apparatus and the method of working, the results of the work carried out on the red-soil (Terra-Rossa) of the Mediterranean of the *Brachypodium ramosum* and *Phlomis lychnitis* association are given. They show that the red, chalky, permeable, calcareous soil is well-aerated throughout the year, to which fact is due perhaps the richness of the association. It contains 200 phanerogamic species and forms the richest association of the Bas-Languedoc. On the other hand, the water-content of the soil is low. This is partly due to the nature of the soil and the low-content of silt and clay (19·3%).

The water-capacity of this red-soil is found to diminish with humidity and increase with dryness of weather. Explanation of these phenomena is given in the paper. The air-capacity, though found to increase in the same way as the water-capacity, can be considered as constant, for it varies, very little during the course of the year. In conclusion the importance of the study of the air-capacity of soils is emphasized inasmuch as it becomes one of the important criteria wherewith to estimate the soil quality and capacity.

104. Studies on the cotton in Central India and Rajputana. II. Osmotic pressure relations between soil solutes and cambodia leaf-sap.

YESHWANT D. WAD *and* SHARASHCHANDRA B. MOGRE,
Indore, C.I.

The leaf roll of Cambodia cotton is the result of the lowering of the concentration of plant sap.

The lowering of the sap concentration follows the excessive rise of soil solutes to the surface layers, both in black cotton soils of Malwa as well as in the sandy soils of Jaipur.

This movement of salts can be kept on effectively and a healthy Cambodia crop can be grown down rain-watered black cotton soils in spite of a very wet season, by merely mixing lightly fired soil, half and half with the surface soil up to a depth of an inch and a half.

Section of Geology.

President :—PROF. K. K. MATHUR, B.SC. (HONS.) (LONDON), A.R.S.M.

Presidential Address.

PROBLEMS OF PETROGENESIS IN THE DECCAN TRAP.

PROFESSOR MEGHNAD SAHA AND GENTLEMEN,

I consider it an honour and a privilege to have been called upon by the authorities of the Indian Science Congress to preside over this section. Before I proceed with my address it is my sad duty to place on record the death of Professor Hem Chandra Das-Gupta on January 1, 1933, just before the Congress met last year at Patna. Ever since the organization of this institution Professor Das-Gupta took an active interest in its deliberations. He presided over the Geology section at its Calcutta session in 1928. He was connected with the Department of Geology of the Presidency College at Calcutta for the last three decades successively as a student, a demonstrator, and a Professor; and those who know the history of geological education in this country will realize what an important part has been played by this college in spreading the knowledge of geology among Indians. Prof. Das-Gupta carried out investigations almost on all branches of geology and took a keen interest in anthropology. In spite of his bad health due to over-work he showed the enthusiasm of a young man in geological research. The foundation of the Geological, Mining and Metallurgical Society of India is a standing monument of his desire to spread the love of research in these branches among Indians. His death has been a great loss in the ranks of non-official geologists in this country.

Coming to my address, I propose to deal with a subject which should be of special interest to those who are assembled here, namely, the Deccan Trap formation which covers the length and breadth of this Presidency and overflows into the neighbouring territories.

In 1867 W. T. Blanford, summarizing the results of five years' close study of the volcanic rocks in Western and Central India, came to the conclusion that the middle and higher traps of the Deccan contained no trace of any sedimentary intercalated beds; they were confined to the lowest flows, cropping out round the edge of the trap area or to the highest flows appearing at Bombay (1867, p. 152).

This fact has provided the basis for the classification of the trappean formation into Upper, Middle, and Lower Traps detailed in the Manual of the Geology of India (Oldham, 1893, p. 262). Fermor and Fox have further subdivided the Lower Traps of Linga (1916) and a similar subdivision of the Upper Traps has been effected by A. B. Wynne (1866) and other investigators on the Geology of the Bombay Island.

The early workers on the Deccan Trap discovered numerous 'trachytic' intrusions in their search for the volcanic foci of the great eruption. These aberrant types occur closely associated with the trap but show remarkable differences in their mineral character and chemical composition. Patient researches have revealed the presence of scattered outcrops of rhyolite, granophyre, syenite, nepheline-syenite, andesite, diorite, olivine-gabbro, peridotite, limburgite and lamprophyre among these rocks. Their occurrence raises the problem of their relationship to the volcanic activity of the Deccan Trap period represented by the horizontally bedded basalts. Of still greater interest is the question of their origin, which brings us face to face with the fundamental problem of the origin of igneous rocks.

PETROLOGICAL TYPES.

The aberrant rocks referred to in the last paragraph may be classified into the following types for purposes of study. They are indicated here without reference to their relative ages which will be discussed in a subsequent part of this article:

(*a*) The 'trachytic' or acid type consisting of granophyric trachyte, rhyolite, felsite, microgranite, and granophyre.

(*b*) Syenite, diorite, nepheline-syenite, monchiquite, and other lamprophyres which constitute the central mass of Mount Girnar.

(*c*) Olivine-bearing rocks consisting of olivine-gabbro, olivine-dolerite, oceanite, peridotite, limburgite, etc.

THE ACID TRAPS.

Modes of occurrence.—The rocks of this group occur as large and small dykes, lava-flows and laccoliths intrusive in the Deccan Trap proper. A list of these, so far as they have been discovered by numerous workers, is given in Appendix A. I shall here consider only a few examples illustrative of their modes of occurrence. Numerous 'felsitic' *dykes* occur in Kathiawar. The peripheral hills of Girnar provide a beautiful example of a *ring dyke* of granophyre intrusive in the basaltic flows (Mathur and others, 1926). The texture of this varies from the zone of contact, where it is fine-grained and shows the spherulitic texture of a keratophyre, to the central portion where it is medium-grained and shows a granophyric texture.

The ring is almost complete ; the north-eastern portion of the circumference missing in the published map (op. cit.) is represented in the ground by fine aplitic veins running with interruptions along the joints in the basalt. In the hills of Utan and Dongri in the western part of Salsette (Mathur and Naidu, 1932) we have a larger *intrusive mass* of microgranite, felsite, and granophyre elongated north and south without much evidence of a lava flow. A *laccolitic* mass is illustrated by Barda Hill of the Porbunder State, micro-sections of which have been described in great detail by E. H. Adye (1917). Among extrusive rocks may be mentioned the *rhyolite flows* of Pavagad Hill (Fermor, 1906) and the two horizontal *flows* of acid lava beautifully exposed in the quarries of Kharodivadi (Krishnan, 1929 and Mathur and Naidu, 1932, p. 795).

A large number of chemical analyses of rocks of this group are now available and they show that they are invariably supersaturated with silica, and generally show the presence of primary quartz. Since no compilation of their occurrences exists in literature it is necessary to make a few observations with regard to some of the localities mentioned in Appendix A.

Observations on selected occurrences.—The white trap of Dharavee has been ascribed by H. C. Das-Gupta to an effusive stage when according to him 'the basaltic magma was passing to a phase more acidic' (1927, p. 128). He mentions a remarkable similarity between his specimen and the one from Kharodi which has been shown by M. S. Krishnan (1929) to be a granophyric trachyte. It is, therefore, probable that at Dharavee we have the southern representative of the series of acid rocks, which, proceeding in a northward direction, are found at Kharodivadi, Salsette Fort, Madh, Daraoli, as far as the hills of Utan and Dongri opposite Bassein (see Appendix A). It is probable that dykes of trachytic agglomerate occur further north, east of Nala Sopara railway station in Bassein. No acid rocks have been discovered still further north until we come to the 'trachytic rocks' of the Rajpipla State described by P. N. Bose (1908, p. 173). This north-south line of acid intrusives may be said to terminate in the rhyolites of Pavagad Hill, the true nature of which was first discovered by Dr. Fermor (1906).

The second series of occurrences of acid rocks forms an east-west line running along the Nerbudda valley and extending westward to Kathiawar as far as Barda Hill in the Porbunder State. The occurrences of the Nerbudda valley have been described by W. T. Blanford (1869, pp. 169, 171, 221) and P. N. Bose (1884, pp. 30, 54, 57). The rocks of the Bhavnagar territories have been examined in detail by K. P. Sinor (1927). I may also refer to the granophyres of Mount Girnar, the rhyolites of Osham Hill, and finally, the acid intrusives of Alech and Barda Hills, the microscopic structures of which have been described by E. H. Adye (1914, 1917).

The two east-west and north-south lines of acid intrusions find their explanation in the structural features of the country. P. N. Bose (1884) noted that the direction of the dykes of the Deccan Trap, in the Chandgarh-Handia metamorphic area, was invariably east-west, which is the direction of strike of the metamorphics in this locality. Evidently the east-west fissures in the underlying metamorphic rocks provided an easy passage for the intrusion of the acid magma. Discussing the evidence of tectonic disturbance in the coastal region Dr. Fox (1922, p. 126) wrote : 'the presence of a great fault out at sea, parallel to the west coast of India, has long been suspected, and it is well known that the hot-springs which occur at intervals along the coastal strip of the Konkan from south of Ratnagiri to north of Bombay, lie on a remarkably straight line indicative of a band of fracture'. The presence of a number of dykes of dolerite in Salsette and Bassein, running more or less parallel to the coast, is a further indication that in this region this direction provided planes of weakness in the crust of the earth, through which the molten magma easily found its way to the surface.

THE GENESIS OF ACID ROCKS.

The genesis of these rocks is intimately bound up with the larger problem of the origin of igneous rocks. During the last 18 years, the hypothesis of crystallization-differentiation has been developed by N. L. Bowen on the basis of his experimental researches on silicate melts, although it has been advocated by Schweig, Daly, and Harker since the beginning of this century and is nearly as old as the science of petrology. In the description of the rocks of Girnar Hills (1926) and during my first study of the acid rocks of Salsette and Bassein (1932) in collaboration with P. R. J. Naidu, I sought the help of this hypothesis to explain the co-existence of acid and intermediate types with the basalt of the Deccan Trap. Leading workers in petrology including C. N. Fenner, A. Holmes, and others have, however, sounded a note of warning in a number of recent contributions against accepting this hypothesis as a general solution of the origin of acid rocks. The alternative hypotheses which we may consider, are, respectively, the pure melting of sial, 'palingenesis', and magmatic assimilation, i.e. the solution of sediments by the magma.

Holmes (1932) has suggested a new method of solving the problem by the estimation of ca_{41}/ca ratio by the magneto-optic method ; but we must await the assistance of physical chemists for the fructification of this idea. Another method lies in the separation and analysis of the glassy base in igneous rocks. This would give us direct information regarding the condition of the residual liquid after the early minerals have crystallized out. In actual practice the separation of the glassy matter from the other minerals by mechanical methods offers great difficulty unless particularly good specimens, with coarsely crystallized phenocrysts in a large glassy ground-mass, are available. In the Indian occurrences outlined above there are, however, certain field observations which have a direct bearing on the origin of these rocks.

Matapenai Hill.—W. T. Blanford (1869, p. 171) described Matapenai Hill as composed of a highly crystalline, greyish trachyte, having somewhat the appearance of a felstone. 'Scattered throughout the mass are huge blocks of granite; these, towards the top of the hill, are so abundant that it might easily be supposed that the metamorphics cropped out there'. Referring to the 'dyke of granite' near Sodawud, north-east of Matapenai, he says 'the occurrence of small veins of granite in the trap is not easily accounted for. *Some of the blocks of granite may have been fused and injected into previously consolidated trap*'. This sounds very much like palingenesis, and the locality deserves careful re-examination.

Mandlesar.—A somewhat similar occurrence has been described by P. N. Bose. Opposite the town of Mandlesar, a dyke of basic rock has carried up large blocks of 'granite' which have been altered near the contact, proving 'the intensity of the igneous force at the place'. According to this author, '*the heat from the dyke must have partially fused the felsitic rock*; the quartz managed to survive, though considerably injured; the other minerals succumbed and were melted' (1884, p. 56). I feel that in these occurrences we have a direct method of solving the origin of the acid associates of the Deccan Trap, since the Matapenai and Mandlesar occurrences lie in the line of dykes of felsitic rocks of the Nerbudda Valley.

THE AGE OF THE ACID TRAPS.

Apart from the genesis of these acid rocks, it is necessary to ascertain their relative age with respect to the main mass of the Deccan Trap. It may be mentioned at the outset that most of the evidences point to an age younger than the main body of basaltic rocks. It is much more difficult to estimate the interval which separated the two sets of igneous rocks.

Kharodivadi.—The 'granophyric trachyte' of Kharodivadi lies in the coastal plain of Salsette. According to R. B. Foote (1876, p. 177) 'the great terrace of the Konkan may be regarded as a vast shelf-like plane formed by marine denudation. The two lava-flows of Kharodivadi appear to have flowed out on this plane. A sufficient interval of time must, therefore, be allowed for the elevation of the Sahyadri Range and the formation of the plain of the Konkan by the action of waves. All the other masses of acid rock in Salsette similarly rise up as isolated hills from the plain near the western coast and are separated from the high range of the Western Ghats by flat salt-plains.

Pavagad Hill.—In Pavagad Hill Dr. Fermor (1906) has assumed an interbedding of rhyolite and basalt, but repeated examination of the hill has given conclusive evidence that rhyolite here is younger than basalt. It lies at different levels in different parts of the hill. It is present in the form of a plug at the highest top and forms the covering of several outlying hills. It even occurs low down at the general level of the country forming an elevation of 559 feet to the south-east of the hill at a distance of about 5 furlongs from the base of the cliff. It appears that all these occurrences had local outlets and that the present topography had been more or less established by the time the rhyolites were poured out. The possibility of the occurrence of faults in this area does not seem to affect these conclusions.

Kathiawar.—In Mount Girnar, granophyre forms a ring-dyke in basalt and all other occurrences of Kathiawar point to a younger age than the basalt. A solitary exception to this rule appears to be an observation by P. N. Bose.

Barwani.—Describing the Barwani 'felstones' he observes that their intrusion was effected through fissures in the basaltic flows and they must consequently have been posterior to the basalts. But 'between Bilda and Bakaner. . . . . .the trachyte is found in abundance. . . . .among the unquestionably basic rocks of the Deccan Trap age. These latter overlie the intermediate igneous rocks in such a manner as to place the greater antiquity of the latter beyond reasonable doubt (1884, p. 30). Again (p. 57) 'the Kawant trachytes, inasmuch as they are overlaid and cut across by what are apparently the lowest beds of the Deccan trap, are of pre-trappean age'. In view of the unanimity of evidence in other areas with regard to the younger age of the felsitic rocks this locally needs careful re-examination.

Helium ratio.—Dr. V. S. Dubey, my old co-worker and present colleague in the Department of Geology at Benares, has contrived a new method of determining the age of a compact igneous rock by the determination of the helium ratio. Discussing this method Dr. Holmes and Dr. Dubey observe (1929) 'Clearly there is a vast field of geological research now open to investigation by the long neglected helium method. If our initial hopes are realized—and these preliminary results provide ample encouragement, a method is now available for dating all fresh igneous rocks which have not been heated up or metamorphosed since they came into place.' With the expected provision of a liquid air plant at Benares it is hoped that work may be commenced next year on the igneous rocks of India. The preliminary investigations of Dr. Dubey, quoted by A. Holmes (1931, p. 413), give an Early Eocene age for the basalt of Pavagad Hill, whereas the acid felsite of the plug on the Mauliya plateau indicates a Miocene age. These conclusions are not at variance with geological field evidence, but many more experiments are needed before full reliance can be placed on the new method, which gives promise of proving highly useful in the determination of the ages of geological formations.

THE OLIVINE-BEARING ROCKS.

A series of olivine-bearing rocks is developed in connection with the basalts and they appear to occupy a place complementary to that of the acid series described above. A list of these is given in Appendix B, but it is hoped that by further researches this list will be greatly augmented. It includes olivine-gabbro, peridotite, limburgite, oceanite, ankaramite, and olivine-basalt, piercing the basaltic flows and, therefore, indicating an age later than the Deccan Trap proper. Other occurrences have been brought to light which indicate that olivine-bearing rocks were present in the early stages of volcanic activity.

Linga area.—Flow No. 2 of the Linga area (1916, p. 93) contains olivine and Dr. L. L. Fermor has mentioned a number of olivine-bearing lava flows, investigated by Mr. W. D. West, from the borings in the Deccan Trap in Kathiawar (1932, p. 18). They include oceanite, ankaramite, limburgites, and olivine basalts. He observes : 'The various types summarized above were extruded one after the other without regard to order, and it is clear that the magmas responsible for each rock-type must have been available for tapping throughout the whole time that eruption was proceeding'. It is, therefore, necessary to differentiate occurrences which are post-trappean from those which are of the same age as the basalts of the Deccan Trap.

Other Occurrences.—In Pavagad Hill ultra-basic rocks occur closely associated with the ashes and tuffs and are older than the rhyolite-flows. The olivine-gabbro of Mount Girnar occurs in the valley round the central mass of diorite. This annular depression is due to the fact that the olivine of this coarse-grained rock is easily decomposed by weathering agencies. Other occurrences of ultra-basic rocks in Kathiawar are intrusions except some limburgites which have been described by E. H. Adye as bedded lavas (1914). To these must be added the oceanites, limburgites, etc. from the borings in Kathiawar referred to by Dr. Fermor (1932). In Cutch the dome-shaped mass of Dhenodhar consists of limburgite, and this type also occurs in Bhujia Hill and other neighbouring hills. H. C. Das-Gupta (1917) has described a limburgite from Baluchistan.

ORIGIN OF OLIVINE-BEARING ROCKS.

Petrologists in different parts of the world have indicated the possibility of gravitative separation of the early-formed minerals to form ultrabasic rock masses, and in India Dr. Fermor (1926, p. 197) has drawn attention to the sinking of phenocrysts of both olivine and labradorite towards the bases of certain Bhusawal lava flows. W. D. West (quoted by Fermor, op. cit.) has investigated the optical properties of olivines and other phenocrysts in the olivine-rich lavas of Kathiawar and has shown that they are highly magnesious. The detailed investigations of Mr. West have not yet been available to me. It is, however, interesting to note that J. H. L. Vogt has made extensive contributions to the theory of crystallization-differentiation by this method which he calls 'the analytic' as distinguished from 'the synthetic' method of N. L. Bowen and others. He has made detailed researches on the nature of olivine in various olivine-bearing rocks, and has given the summary of his conclusions (1924, pp. 11, 26, 27). The olivine of gabbros, norites, anorthosites, and related rocks contains on an average about 30 per cent. Fe_2SiO_4. Some few optical determinations give 2V as high as 85 degrees equalling about 25 per cent. Fe_2SiO_4. This value rarely rises as high as 40 per cent. Fe_2SiO_4. The peridotites, on the other hand, carrying olivine, varying from 40 to almost 100 per cent., show a parallel variation of Fe_2SiO_4 in the olivine from a maximum of about 12 per cent. to a minimum of 7 per cent. This distinguished author arrives at the conclusion that peridotites and dunites have crystallized from a 'proto-enriched magma' formed by the subsidence and complete resorption of the early crystallizing minerals. It appears that the olivine-bearing associates of the Deccan Trap may thus have two types of origin, depending on whether they crystallized from the 'normal' basalt, or from an ultra-basic melt. The nature of the pyroxene provides a further criterion as has been pointed out by Dr. Fermor (op. cit.). It is difficult to say whether the Indian occurrences will provide a clue to the ultimate source of the ultra-basic magma. The problem involves a consideration of the physical conditions at some depth in the interior of the earth. Arthur Holmes has assumed a primary peridotite layer which under certain conditions may be injected into the crust of the earth. He is opposed to the idea of a basaltic parentage for some of the peridotites (1932, p. 553).

THE IGNEOUS COMPLEX OF MOUNT GIRNAR.

This interesting mountain rises from the basaltic plateau of Kathiawar. At the suggestion of the late Dr. J. W. Evans, I mapped the area with the collaboration of my two former students, Messrs. V. S. Dubey and N. L. Sharma (1926), whereas a description of a collection of rocks was published by Dr. M. S. Krishnan (1926). The principal rock types comprised in the mass, besides basalt, are olivine-gabbro, granophyre, hastingsite-bearing diorite and syenite, nepheline-syenite, and a variety of lamprophyres including monchiquite. At the time of our field investigations we made an attempt to apply the theory of fractional-crystallization to the origin of these rocks. The acid and the olivine-bearing members of this mountain, however, separately belong to the two large groups which have been mentioned before and their genesis in this area must be in conformity with the general theories which may be found adequate, to explain the origin of each group. We are then left with the rocks of the central mountain which are of an intermediate character ; and they include a type which was the cause of a 'spirited discussion' in a meeting of leading petrologists of the world at Magnet Heights, on the occasion of the Fifteenth International Geological Congress in South Africa, a glimpse of which has been preserved to us by S. J. Shand (1930, p. 416). The literature on the origin of nepheline-syenite published in recent years by competent authorities is full of scientific interest, but it will be of little use to recapitulate the arguments on this occasion. I wish to point out a few facts which will have to be taken into consideration in the elucidation of the origin of this rock in Mount Girnar.

Its genesis is intimately connected with the syenite and diorite of this hill by the presence of a common mineral which I (in collaboration with Mr. Jhingran) have distinguished under the sub-species 'Girnarite' (1931, p. 100). It is also intimately associated with the masses of lamprophyre in a manner which suggests great fluidity of the falspathoidal magma at the time of its consolidation. There is very little doubt that the dark masses of lamprophyre are largely composed of small crystals of the ferromagnesian minerals which occur in the associated diorite and syenite and represent segregations from these magmas. A detailed microscopic study of rock specimens collected by us has been made at Benares by Mr. A. G. Jhingran and there is evidence in favour of assuming a discontinuous reaction relationship among the ferromagnesian minerals of the type $\text{Olivine}\rightarrow\text{Brown augite}\rightarrow\text{Green augite}\begin{array}{l}\nearrow\text{Biotite}\\ \searrow\text{Girnarite}\end{array}$ (the Girnar amphibole). The felspars of these intermediate types are often clouded with kaolin and optical determinations did not enable us to trace the continuous reaction series which according to Bowen's theory should be shown by the felspars of the rocks derived from basalt. It is proposed to carry out chemical analyses of the felspathic portions after their separation by heavy liquids in the hope that these will throw some definite light on the genetic relationships. I may also record another fact of some importance. The granophyric ring-dyke is confined to the peripheral hills but a quartz-bearing rock was obtained from a well on the main road at the eastern foot of the central mountain, where veins of nepheline-syenite are abundant, and there is a possibility that by patient search quartz-bearing dykes will be discovered in the area within the olivine-gabbro. Much field and laboratory work is needed before we can arrive at a true solution of the origin of these rocks.

One has to consider various possibilities. We have the crystallization-differentiation hypothesis of Bowen which may give us the complete suite consisting of olivine-gabbro, diorite, syenite, nepheline-syenite and granophyre. In case, however, it is proved that the granophyric rock has its parentage in a separate magma, we are left with the problem of the intermediate rocks. However difficult and disagreeable the idea of limestone-assimilation, as an explanation of this occurrence, may appear to us, we cannot say that Jurassic limestones which crop out in the neighbouring state of Cutch do not exist underground below the Deccan Trap. I have mentioned these points only to indicate the bearing of the various facts on the problem before us.

GEOLOGY OF BOMBAY.

Before I close I wish to invite your attention to certain problems in the Geology of the Bombay island. The rocks of this area have been examined and described by distinguished workers since the early half of the last century. A. B. Wynne, as a result of his systematic geological examination of the area (1866), established a conformable series of lava flows and interbedded sedimentary beds dipping gently 10°–15° to the west. Dr. C. S. Fox (1922, p. 117) during a close examination of the rocks came to the conclusion that the dolerite of the Sewri quarry was an intrusive sheet, and that the lower trap of Warli Hill was also an intrusive rock and lithologically similar to that of Sewri. Assuming the two as parts of one sheet, he has postulated a strike fault whereby the succession of rocks in the eastern line of hills, namely, in Antop Hill, Sewri Fort and Nowroji Hill, is repeated in Malabar, Cumballa and Warli Hills. Then we have to consider the position of the Dharavee rock which (as I have shown before) is likely to prove to be a felsite. The correlations of Dr. Fox were largely based on an examination of hand-specimens and it is possible to place these conclusions on a sounder footing by a chemical examination of the rocks concerned.

A basalt obtained between Race Hill and Seoree has been analysed by Washington (1922, p. 774). It has been pointed out by V. S. Dubey (1929) that this rock differs from the other analyses in showing a somewhat higher alkali percentage than the average of the remaining rocks. The upper trap of Malabar Hill has been analysed by P. R. Jagapathy Naidu (1932, p. 801) and another rock from Pali Hill in Bandra, which is geologically a continuation of Malabar Hill, has been analysed by V. R.

Khedkar (1934). Both analyses show that the trap is an andesite. The presence of sub-basic rock and of the 'white trap' of Dharavee proves that the trappean rocks of Bombay are somewhat different from the average plateau basalt in their structure and chemical composition, and deserve further study.

Gentlemen, I do not wish to detain you longer with other problems of petrological interest in this formation. With the diversity of types which occur in it, a study of their origin would cover the vast region of igneous petrology with all the intricacies of petrogenesis which await solution. I have not attempted to trace the igneous equivalents of this formation in Persia, Arabia, and the extra-Peninsular regions of India. The history of the Deccan Trap period is intimately connected with the breaking up of the Gondwana-land and the elevation of the Himalayan chain. A proper appreciation of the events demands a correlation of these facts with the physical changes in the depths of the earth of which the trappean intrusions and flows are but a surface manifestation. A celebrated Anglo-Indian poet, who was born in this city, wrote :

> 'And he knows not England,
> Who only England knows'.

This may truly be said of the Deccan Trap. Its roots lie deep down in the bowels of the earth, and its branches are spread far and wide over its continents. The geologist of the future will be expected to apply himself to the elucidation of the broader and more fundamental aspects of this formation, and the task demands a synthesis of knowledge in the domains of astronomy, geo-physics, and physical chemistry.

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APPENDIX A.

A list of Acid rock-masses associated with the Deccan Trap.

No.	Name of rock as given by the author.	Sp. gravity.	Form of Rock Mass.	Locality.	Author, year, and reference.	Reference to Chemical analyses, if any.
1	White trap ..	2·30	....	Dharavee (19°·3′; 72°·51′).	Das-Gupta, H. C. (1927).	....
2	Granophyric trachyte.	2·431	Two lava flows.	Kharodivadi (19°-12′; 72°-49′).	Krishnan, M. S. (1929).	P. 373.
3	Rhyolite and micropegmatite.	2·67	Lava and minor intrusion.	Daraoli. Madh and Salsette Fort (19°-8′-10′; 72°-47′).	Mathur, K. K. and Naidu, P. R. J. (1932).	P. 801.
4	Granophyres, rhyolites and trachytes.	2·2 to 2·65	Do.	Western Salsette ..	Mathur, K. K. and Khedkar. V. R. (1934).	Table P. 5.
5	Trachytic agglomerate.	2·38	Dyke ..	Kalmapad (19°·25′; 72°·50′).	Mathur, K. K. and Naidu (1932).	P. 801.
6	Trachytic rocks ..	....	Intrusive	Karia Hill (22°·19′; 73°·20′). Bardaria Hill (22°·20′; 73°·22′). Another hill (22°·21′; 73°·20′).	Bose, P. N. (1908)	....
7	Trachyte ..	....	Do.	Matapenai Hill (22°·12′; 73°·53′).	Blanford, W. T. (1869).	....
8	Granite	....	Dyke ..	Do. near Sodawud..	Do.	....
9	Trachyte ..	....	Intrusion	Tarkachla (22°·2′; 74°).	Bose, P. N. (1884)	....
10	Felsite	....	Do.	Atarsuma (22°·8′; 74°·42′). Dharamrai (22°·3′; 74°·45′). Barwani (22°·2′; 74°·59′). Mandlesar (22°·10′; 75°·44′).	Do.	....
11a	Rhyolite, breccia. rhyolitic ash, and pitchstone.	2·33 to 2·54	Lava-flow	Pavagad Hill ..	Fermor, L. L. (1906).	P. 158.
11b	Do.	....	Plug and lava-flow.	Do.	Dubey, V. S. (1929).	Pp. 27, 28, 31, 35.
12	Felsite, porphyritic felsite.	2·53 to 2·5	Dyke ..	Rajpura (21°·44′; 72°-14′).	Sinor, K. P. (1927)	....
13	Obsidian.. ..	2·3	Do.	Rajpura (21°·21′: 72′·5′).	Do.	....
14	Quartz-felsite ..	....	....	Sobhavad and Sakhnasar (21°-20′; 72°-4′).	Do.	....
15	Felsite	2·54	....	Sihore and Satsheri Hills (21°·43′; 72°·1′).	Do.	....
	Pitchstone ..	2·4 to 2·5	....	....	....	....

No.	Name of rock as given by the author.	Sp. gravity.	Form of Rock Mass.	Locality.	Author, year, and reference.	Reference to Chemical analysis if any.
	Rhyolite	2·51	....	....	....	....
16	Granophyre ..	2·50 to 2·52	....	Chamardi (21°·50′: 71°·58′).	Sinor. K. P. (1927)	....
17	Quartz-felsite (with tourmaline).	....	....	Loingdi (21°·12½′: 71°·57′).	Do.	....
18	Devitrified rhyolite	2·65	....	Jethri-Piperla (21°·43½′; 71°·56′).	Do.	....
19	Granophyre, felsite. devitrified pitchstone and rhyolite breccia.	2·62	....	Chogat (21°·49½′: 71°·55′).	Do.	....
20	Felsite	2·55	....	Sarod (21°·14′; 71°·37′). Nava Japura.	Do.	....
21	Obsidian ..	2·22 to 2·25	....	Two miles south of Palyad (22°·14′; 71°·37′).	Do.	....
22	Quartz-felsite ..	....	....	Babariadhar (21°·9′; 71°·37′). Kherali (21°·8′: 71°·34′). Rajula (21°·2′: 71°·30′).	Do.	....
23	Spherulitic granophyre, pitchstone and rhyolite.	....	Intrusion	Gir Forest ..	Chatterji, S. K. (1832).	....
24	Rhyolite	2·56	....	Patanwas (21°·38½′: 70°·19′).	Krishnan, M. S. (1926).	P. 418.
25	Micro-granite, quartz-porphyry.	....	....	West of Mandlekpur (21°·29′: 70°·40′).	Do.	....
26	Quartz-porphyry ..	....	....	Do. ..	Do.	....
27	Pitchstone ..	....	....	North-West of Valaria (21°·37′; 70°·21′).	Do.	....
28	Augite-granophyre	....	....	Just east of Wadela	Do.	....
29	Rhyolite and spherulitic obsidian.	....	....	Osham Hill ..	....	....
30	Granophyre ..	2·59 to 2·74	Ring Dyke.	Mount Girnar ..	Mathur, K. K. and others (1926). Jhingran, A. G. (1930).	....
31	Granophyres, felsites, rhyolite and obsidian.	....	....	Alech Hills ..	Adye, E. H. (1914)	....
32	Rhyolite and obsidian.	....	....	Barda Hills, Nagka-Rajhora dyke.	Do.	....
33	Felsite (spherulitic) porphyritic felsite, granophyre.	....	....	Barda Hills ..	Do.	....
34	Orbicular granophyre.	....	....	Gured Dhar near Godhana (Barda Hills).	Do.	....

APPENDIX B.

A list of olivine-bearing rocks associated with the Deccan Trap.

No.	Name of rock as given by the author.	Sp. gravity.	Form of rock mass.	Locality.	Author, year, and reference.	Reference to chemical analyses, if any.
1	Olivine-basalt ..	....	Lava-flow	Linga area, Chhindwara (21°·55′; 78°·55′).	L. L. Fermor (1916).	....
2	Do.	2·87, 2,90, 2·91	....	Bhusawal ..	Do. (1926, pp. 232, 237).	
3	Olivine-dolerite, oceanite, ankaramite.	....	Intrusion	Pavagad Hill ..	V. S. Dubey (1929, Pt. 2, p. 24).	Pt. I, p. 38.
4	Olivine-dolerite ..	2·94 2·96	....	Bhimrad, Salaiya, and Dhrupania.	K. P. Sinor (1927, p. 46).	....
5	Do.	....	....	Hill near Sonaria, Asodriali, Nes, and Kapuria Nes.	Chatterji, S. K. (1932).	P. 162.
6	Olivine-gabbro ..	....	....	Mount Girnar ..	M. S. Krishnan (1926).	P. 418.
7	Limburgite ..	....	Lava-bed	Sona Dungar ..	E. H. Adye (1914, p. 92).	....
8	Olivine-dolerite ..	....	....	Extreme S. E. districts of Navanagar State.	Do.	....
9	Limburgite ..	....	Bedded lava.	Waori, near Bhadla	Do. (p. 94) ..	....
10	Picritoid-dolerite ..	....	Dyke ..	Do. ..	Do. (p. 95) ..	....
11	Limburgite-basalt ..	....	Bed of lava.	Police Chowki ridge, Bhadla.	Do. (p. 97) ..	....
12	Ultra-basic lavas ..	....	Lava ..	Kathiawar ..	L. L. Fermor (1932).	....
13	Limburgite ..	....	....	Bhujia Hill .. Dhenodhar Hill and other neighbouring elevations.	Personal observations.	....
14	Limburgite ..	2·94	Bedded ..	Hamandun (30°·28′; 67°·24′).	H. C. Das-Gupta (1917).	P. 295.

Section of Geology.

Abstracts.

1. Experiments with the Automatic Water-Finder.

N. G. APTE.

In the Bombay Presidency the Agricultural Department has attempted to locate water with the help of the Water-Finding machine designed by one Mr. Schmidt and manufactured by Messrs. Mansfield & Co., Liverpool. The working of the machine depends upon the vertical earth currents according to the manufacturers. According to the instructions that are sent with the machine it should work for about eight hours in the day. The design of the machine is very simple. It has two chambers; the lower one is sealed and it contains a steel wire coil wound round a spindle. In the above chamber is a pivot on which the magnetic needle is placed while working the machine. It is by the oscillations of this needle that the quantity of water is estimated. It is only in the mornings that the machine gives reliable results. A heated soil also affects the working. The machine has got its limitations and has to be worked with due caution. The successful working needs a well-trained operator who can differentiate between the movements due to an underground current or otherwise, as many times certain factors that affect the working escape notice of even a cautious worker. Besides he has to be well-trained in the Geology of Water Supplies so that he can approximately fix the water-bearing locality.

2. Reflexions on some aspects of the Geology of Bombay.

JAYME RIBEIRO.

The author after reviewing the facts as observed or ascertained by him comes to the following conclusions:—

1. (*a*) That six of the original seven islets which form the nucleus of the present Island of Bombay owe their origin to a sudden subsidence of the surrounding land;

(*b*) That this event took place after the volcanic activity that gave rise to the traps and breccias had ceased;

(*c*) That subsequent to this there have been some slight rises and falls in the levels of Bombay;

(*d*) That the seventh islet, Mahim, is a sand bank.

2. That the jasperised rock of Antop Hill was emitted from a crack in the crust extending from the south end of the harbour to Antop Hill in the north.

3. (*a*) That the sedimentary beds of Worli-Camballa-Malabar Hills were deposited by a river which flowed from the north, at a time when the coast line was far away;

(*b*) That the sea approached the beds by the probable subsidence of a vast tract of land on the west subsequent to the outburst of scoriaceous trap and prior to the basaltic lava flow;

(*c*) That the sea partially covered the beds owing to the later dip of 15° to the west;

(*d*) That the other fresh water deposits took place in lagoons earlier than the Worli beds.

4. That the scoriaceous trap issued from three parallel cracks in the ground giving rise to (*a*) Malabar-Worli-Bandra Hills, (*b*) Sewri-Golanji-Rowli Hills, (*c*) Nowroji-Sewri Cemetery Hills.

5. That the basaltic trap issued from a point where the harbour now is, or a little beyond it, in a north-westerly direction.

3. Notes on the Geology of the Lower Cuddapahs.

C. PRASANNAKUMAR *and* M. R. SRINIVASA RAO.

As a result of a recent detailed study of the Lower Cuddapahs in the field, several interesting facts have been noticed and these are briefly described in the paper. Special attention is drawn to the stratigraphical position of the included traps, and from their behaviour towards the adjacent rocks, the exact character of these trap flows is discussed.

4. Probable horizon of the Nandikonda-Chintalpalem Conglomerates in relation to the associated quartzites.

L. S. KRISHNAMURTHY *and* C. MAHADEVAN, Hyderabad.

Between Nandikonda (Lat. 16° 35′; Long. 79° 18′) and Chintalpalem (Lat. 16° 35′; Long. 79° 23′) in Nalgonda District H.E.H. the Nizam's Dominions, along the north bank of the Krishna river, some beds of conglomerates have been noted in association with quartzites. Due to want of adequate stratigraphical evidence, the age of these beds with the associated quartzites has not been clearly defined.

The paper describes the petrological characters of the various pebbles and the matrix constituting the conglomerate, and discusses the probable horizon of the formation, in relation to the occurrence of old diamond mines in the neighbourhood.

5. Detailed Stratigraphy of the Jumara Area, Cutch.

RAJ NATH, Benares.

The author mapped parts of western Cutch on a scale of 1″=1 mile in the year 1927 showing the outcrops of the series of Patcham, Chari, Katrol, and Umia separately. An area in the western region of Cutch and near the village of Jumara was mapped in greater detail on a scale of 4″=1 mile. The Patcham and the Chari Series were sub-divided into 26 divisions and fossil collections were separately made from each. These beds form a denuded dome and show a beautiful set of radial dip-faults. There are minor igneous intrusions in the area affecting these beds.

6. Detailed Stratigraphy of the Nari beds west of Bagatora Railway Station, Sind.

K. K. MATHUR, G. W. CHIPLONKER, *and* M. L. MISRA, Benares.

The area west of Bagatora (26° 21′, 67° 55′) was visited and a large collection of fossils was made bed by bed from the Nari formation. It was also mapped on the scale of 1″=1 mile. The Kirthar limestone forms the exposed base of a dome and is succeeded on the west by scarps of Lower Nari, unfossiliferous Upper Nari (or Gaj) and the Manchhars. Blown sand and alluvium cover large tracts on all sides. The Lower Nari Series which consists of thin limestone beds interstratified with thick variously coloured shales, is divided into four zones, the fourth being further divided into five sub-zones. This zonal division of the Lower Nari Series in the field is supported by the palæontological study of gastropods and nummulites.

7. Notes on the Geology of Vengurla. II.

K. V. Kelkar *and* P. K. Lohogaonkar, Poona.

The paper includes supplementary notes on the Geology of Vengurla, results of chemical analyses and a map of the area on a scale of 1″ to a mile.

8. Notes on the occurrence of ferruginous quartzites in the Dharwar rocks of the western part of the Raichur Doab.

H. S. Krishnamoorthy, Hyderabad.

Parallel bands of Ferruginous Quartzites have been noted running in a south-easterly direction from Mudenur (Lat. 15° 53′ and Long. 76°18′) to the north bank of the Tungabhadra river, in broken continuity, for a distance of about 40 miles; but they are best developed between Mudenur and Kalmingi (Lat. 15° 43′ and Long. 76° 32′). They have been found in close association with the chloritic schists of the Dharwar rocks. Several interesting structural features are exhibited by the bands, locally and regionally, and seem to be of the nature of interformational sills in the chloritic bands. The paper discusses their mode of occurrence, structural features, petrological characters and field relations with the other members of the Dharwar Series.

9. The Gwalior Trap.

M. P. Bajpai, Benares.

The trap is exposed at Gwalior, Morar, Barai, Paniar, Chaura, and Mo in the Gwalior State. It occurs in the Morar Series as sills, dykes, and lava flows. There are two types. One is a porphyritic quartz-dolerite containing some biotite. The other is a fine-grained basalt. In both the augite has suffered uralitization. Six chemical analyses show constancy of composition, the average values being silica 50·20, alumina 11·73, ferric oxide 2·01, ferrous oxide 11·94, lime 10·21, magnesia 5·45, soda 4·47, potash 0·94, titania 1·59, phosphorus pentoxide 0·74, manganous oxide 0·49, and water 0·81. The values generally agree with Washington's average for the Deccan Trap except that the Gwalior Trap is somewhat richer in alkalis.

The ferromagnesian minerals were separated from three rocks and analyzed. A comparison of the ratios of magnesia to ferrous oxide shows that the pyroxene is richer than the corresponding rock and supports the view that crystallization enriches the magma in iron contents.

The helium ratios for these rocks determined by Dr. V. S. Dubey give an average of 500 million years which agrees with the Upper pre-Cambrian age of the Gwalior Series.

10. Notes on Deccan Trap in parts of Gulbarga and Osmanabad districts, Hyderabad State.

C. Mahadevan *and* L. S. Krishnamurthy, Hyderabad.

Parts of Gulbarga and the whole of Osmanabad district are covered with Deccan Trap flows lying mostly in a horizontal disposition. In parts of Osmanabad district, several escarpments, road and railway cuttings, facilitate an accurate study of the nature and sequence of these flows.

The paper describes the field relations and petrological characters of the various Trap flows. Laboratory determination of porosity of type specimens including those from decomposed layers of Trap have been made and these observations incidentally discussed in relation to the water-bearing capacity of the different flows.

11. The outcrop of the Deccan Trap at Jakhmari in Sind, and its contact-metamorphic effect.

K. K. Mathur *and* Bhaskar Rao Vaddadi, Benares.

The trap is a porphyritic medium-grained dolerite, consisting of labradorite, augite, magnetite, and glass, which is yellowish orange in thin sections. The pyroxene has a biaxial angle of 62°. A chemical analysis gave silica 46·24, alumina 14·68, ferric oxide 8·13, ferrous oxide 4·16, titania 1·14, lime 12·04, magnesia 6·62, soda 4·42, potash 0·22, carbon dioxide 0·51, water 2·60, total 100·76. Both in its chemical composition and in the nature of pyroxene it differs from the typical plateau basalt of the Deccan Trap.

It is probably a lava flow and dips towards W 20° S at an angle of 50°. At its bottom occurs a metamorphosed felsite-looking rock with porphyroblastic texture. The recrystallized minerals are albite, anorthite, calcite, some magnetite, and a palagonitic substance. Its composition is silica 40·47, alumina 20·69, ferric oxide 2·40, ferrous oxide 1·29, titania 0·18, lime 20·84, magnesia 1·65, soda 4·92, potash 0·48, carbon dioxide 7·10, water 0·25, total 100·27. It appears that the rock is a calcite-hornfels and has probably resulted from the contact-metamorphism of a calcareous clay.

12. Geology of Pavagad Hill.

V. S. Dubey, Benares.

This hill has previously been studied by W. T. Blanford, L. L. Fermor, and E. J. Beer. Detailed mapping carried out by the author in collaboration with K. K. Mathur shows that rhyolite and basalt are not interbedded. It was originally an isolated terraced hill of basaltic lava flows typical of Deccan Trap. It was intruded by an ultrabasic magma rich in olivine crystals, with which considerable amount of basic tuff was also thrown out. This was followed by the eruption of acid material from several vents giving rise to rhyolite. The turret at the hill top is an intrusive plug and not the remnant of a bed of rhyolite. Flows of rhyolite occur on the surface at all levels showing that this was the last phase of igneous activity and was much later than the Deccan Trap. Complete analyses and petrographic descriptions of basalt, tuff, olivine gabbro, and rhyolite by the author are given in the paper, together with determinations of radio-activity and helium contents. The helium ratio for an acid felsite indicates an age of 5–5·9 million years which corresponds to the Miocene period and indicates an age later than that of the Deccan Trap.

13. The Trap of Pali Hill, Bandra, Bombay.

V. R. Khedkar, Benares.

The rock is compact and greyish black. The fracture is subconchoidal, and the broken edges are sharp like the Trap of Malabar Hill with which it agrees in all details. A chemical analysis gave silica 51·36, alumina 18·19, ferric oxide 0·17, ferrous oxide 10·80, magnesia 1·11, lime 8·38, soda 4·71, potash 1·09, water 1·82, titania 1·04, phosphorus pentoxide 0·98, manganous oxide 0·17, carbon dioxide 0·09, total 99·94. A thin section shows felt-like laths of felspar in a ground-mass of granular augite, iron ore, and dark brown glass. Olivine is extremely rare. A micrometric analysis gave plagioclase 29·3, augite 20·2, iron ore 9·8, and glass 41·7. Following the nomenclature of Washington the rock may be termed andesine-andesite.

14. The Granophyres, Rhyolites, and Trachytes of Western Salsette.

K. K. Mathur *and* V. R. Khedkar, Benares.

The rocks from this area have previously been studied by M. S. Krishnan, K. K. Mathur and P. R. Jagapathy Naidu. Chemical analyses and micrometric measurements of a large collection made by the author have been carried out. The magmatic relationship of the isolated occurrences are indicated by the following data:—

Area.	Percentage of modal quartz by weight.	Total silica (Average).
(1) Utan and Dongri ..	40·98–49·74	74
(2) Madh and Salsette Fort ..	40·91–43·15	72·5
(3) Kharodivadi and Manori ..	11·48–20·26	62

The authors conclude from the above that the rocks (Granophyres and Rhyolites) of the first two areas are derived from a common source, whereas the rocks of Kharodivadi and Manori are poorer in silica and correspond to granophyric trachyte.

As has been pointed out by previous workers that the lavas of this group flowed out on the coastal plain of marine denudation and appear to be later in age than the Deccan Trap of the Western Ghats.

15. A note on the petrified palms from Mohgaon Kalan, District Chhindwara, C.P.

K. P. Rode, Benares.

This article deals with a number of specimens of petrified palms collected by the author during the last four years from a small village Mohgaon Kalan in the Chhindwara District, C.P. In two previous articles the author has described in detail the anatomical characters of three new species of fossil palms from this area. In the present article three more species of palm stems have been briefly described from the same collection. They necessitate the creation of the following three new species :—

Palmoxylon solidum, *P. mohgaonensis*, and *P. invaginatum*.

There are several specimens of fossil palms still awaiting investigation and are likely to yield some more new species.

All these specimens come from the Upper Cretaceous Intertrappean Beds.

16. On *Rhizopalmoxylon penchiensis* sp. nov.—a fossil palm root from Mohgaon Kalan, District Chhindwara, C.P.

K. P. Rode, Benares.

The specimen described in this article was collected by the author along with a large number of petrified angiospermous plants from the above locality.

Of the few root types obtained from this area the one described here is the most abundant and conspicuous. The preservation in silica is excellent giving the minutest details under the microscope. The type of anatomy observed in the specimen is essentially the same as that in the living representatives of the palm family. As this find is almost the first of its kind in India comparision with other fossil palm roots from this country is not possible. The author has attempted a comparision with the few fossil palm roots described from other countries, as also with the numerous types of roots of the living palms. The specimen is assigned to the form genus *Rhizopalmoxylon*, Felix, while the specific name is from the important river Pench flowing close by. The specimen belongs to the Intertrappean beds of Upper Cretaceous age.

17. A note on a fossil dicotyledonous wood from Mohgaon Kalan, District Chhindwara, C.P.

K. P. Rode, Benares.

In this article the author has briefly described the anatomy of one of the several specimens of fossil dicotyledonous wood collected from the intertrappean rocks of Mohgaon Kalan. The specimen described here is characterised by medullary rays, mostly one cell thick, separating groups of large wood vessels which are very commonly in pairs. The annual rings, though present, are not conspicuously marked off under high magnification.

The author in attempting to compare the anatomical details of this wood has noted the extreme difficulty of such a comparision in the absence of any regular scheme of classification of dicotyledonous plants on the anatomical basis. Of the few dicotyledonous plants having medullary rays one cell thick the nearest approach, so far as the author is aware, appears to be *Juglans*. The author has therefore provisionally named the fossil wood as *Parajugloxylon mohgaonensis* suggesting thereby not the generic identity with *Juglans* but its close approach.

18. Palæontological study of nummulites from the Laki Dome and the Hills near Bagatora, Sind.

Raj Nath *and* M. L. Misra, Benares.

During the course of the field work when a zonal sub-division of the Lower Nari was being attempted, a large collection of fossils was made bed by bed from areas west of Laki (26° 16′, 67° 57′) and Bagatora (26° 21′, 67° 55′). The palæontological results based on the study of the nummulites support the proposed division of the Lower Nari Series into four zones, and the further division of the fourth zone into five sub-zones. These divisions are characterised either by certain restricted species or by a suite of species.

19. On a fossiliferous quartzite from the Trichinopoly Cretaceous.

L. Rama Rao *and* C. Prasannakumar.

The paper describes a fossiliferous quartzite from the Trichinopoly Cretaceous. In micro-sections the rock is a typical quartzite, showing a regular mosaic of quartz grains. Corals like *Heliastrea*, *Holocœnia*, a few foraminifers of the family Miliolidæ, and abundant algæ—chiefly *Lithothamnion*—are the common fossils. The rock must originally have been a fossiliferous sandstone, subsequently silicified. Such a secondary fossiliferous quartzite is a very unusual type of rock and is therefore of interest.

20. Rhynchonellids from the Bagh beds near Cheerakhan, Gwalior State.

Raj Nath *and* G. W. Chiplonkar, Benares.

The Bagh beds, constituting the marine facies of the Cretaceous of the Narbada valley, have, ever since their discovery by Col. Keatinge in 1856, been a subject of considerable interest because of the faunal contrast they present to the Trichinopoly Cretaceous. So far echinoids and ammonites have been described from the Bagh beds and on the basis of the echinoids Duncan has assigned the Cenomanian age to this formation. The authors describe a Rhynchonellid fauna from these beds, which is characterised by fine acute ribbing regularly developed, a hypothyrid to sub-mesothyrid collared foramen, pear-shaped muscle-areas and weak dorsal median septum. These characters indicate a Cretaceous age.

21. Revision of the Jurassic brachiopod fauna of Cutch.

RAJ NATH, Benares.

The author, during his field work in the year 1927, made a large collection of brachiopod fauna along with other invertebrate fossils from the Jurassic beds of Cutch. The last detailed investigation of the brachiopods from this area was made by Dr. Kitchin in the year 1900. In view of the recent advances in our knowledge of the brachiopod group made since then, the author thought it necessary to undertake a revision of this fauna. The important results of this investigation, embodied in this paper, are :—

(1) the creation of four new species (*Lobothyris soorkaensis, Loboidothyris ? patchamensis, L. ? kitchini,* and *Streptorhynchus ? jumarensis*),
(2) a revision of the geological range of certain species,
(3) possible extension of the Productus beds of the Salt Range to some parts of Cutch deduced from the occurrence of a derived Palæozoic form in the Jurassic beds.

22. Palæontological study of gastropods from the Laki Dome and the hills near Bagatora, Sind.

RAJ NATH *and* G. W. CHIPLONKAR, Benares.

While working out the zonal sub-divisions of the Lower Nari, an extensive collection of fossils was made from areas west of Laki (26° 16′, 67° 57′) and Bagatora (26° 21′, 67° 55′). The gastropods from this collection were taken up for palæontological study. As the collection was made bed by bed, it has been possible to study the vertical distribution of the species; as a result of such work the Lower Nari Series is divided into four zones, the uppermost of which is further divided into five sub-zones; so that palæontological results are in agreement with the field evidence. The study of nummulites also support these results.

23. A new species of oxyglossus from the Frog-beds of Warli Hill, Bombay Island.

G. W. CHIPLONKAR, Benares.

The small frogs from the Frog-beds of Bombay Island have long since been known as *Oxyglossus pusillus* (Owen). A recent collection of these fossil frogs from the Frog-beds of Warli Hill, on the west coast of Bombay Island, has revealed a new species of frogs occurring associated with *Oxy. pusillus* (Owen). It probably attained a slightly bigger size than *Oxy. pusillus* (Owen); the length of the head is a little less than the width; the sacral vertebra, including ilia and ischia, is more than two-thirds of the vertebral column and the posterior limbs are one and two-thirds times longer than the body. Other associated fossils are minute Crustaceans and carbonised vegetation.

24. On a Stegosaurian humerus from the Lameta beds of Jubbulpore.

D. K. CHAKRAVARTI, Benares.

The author describes the left humerus of a Stegosaurian dinosaur, which was collected by him from near the junction of the mottled nodular beds with the upper limestone exposed on top of the Chota Simla hill at Jubbulpore. No other humerus of any other orthopodous (ornithischian) dinosaur has yet been found in India. The present find is therefore of considerable interest.

The humerus described cannot be assigned to the only known Indian orthopod, *Lametasaurus indicus*, in the absence of any humerus found for the latter. On the other hand, considering the small size of the present bone and the fact that it has been found on a horizon which is sixty feet or more above the horizon of *L. indicus*, it may be regarded as belonging to a different genus.

This is also corroborated by a study of the description and figures of the other skeletal parts of *L. indicus*. The present humerus differs from all other humerii known, but less from Stegosauridæ than any other family.

25. A study of equine molar teeth from the Older Gangetic Alluvium of Benares.

D. K. CHAKRAVARTI *and* BHASKARA RAO VADDADI, Benares.

The authors describe two equine teeth, one the first left lower molar and the other the first right lower molar, obtained from the Older Gangetic Alluvium in the District of Benares. No equine molars have yet been reported from the same formation. This justifies a detailed study of these teeth. After comparing the present teeth with all the available homologous teeth described or figured, or exhibited in the Indian Museum in Calcutta, the authors come to the conclusion that one of these shows strong affinity with a specimen of *Equus namadicus*, and that the other appears to be a new species.

26. On the systematic position of *Lametasaurus indicus*.

D. K. CHAKRAVARTI, Benares.

The name *Lametasaurus indicus* was provisionally proposed by Dr. Matley for the so-called Indian Stegosaurian, which is represented by a sacrum, a pair of ilia, a left tibia, two lateral spines and many scutes. Later, a number of tabular scutes and a terminal caudal plate were also known. According to Dr. Matley this Indian specimen approaches the genus *Omosaurus* in most respects. This latter genus closely resembles *Stegosaurus*, and as such *L. indicus* has been placed by Dr. Matley in the family Stegosauridæ. But in the second revised English edition (1932) of Zittel's text-book of Palæontology, Vol. II, it has been provisionally placed in the family Nodosauridæ. This is perhaps due to the fact that the tabular scutes resemble those of *Palæoscincus*, other scutes and spines those of *Polacanthus* and the terminal caudal plate that of *Ankylosaurus*—all these three genera coming in Nodosauridæ.

The present author points out that the skeletal remains referred to *L. indicus* cannot belong to a Stegosaur or a Nodosaur, and that they are not probably the associated parts of the same reptile. In view of the great importance of the find, a closer comparative study of the bones should be made.

27. The relationship of the siliceous veins with the associated Dharwar rocks in the Raichur Doab.

S. K. Mukerji, Hyderabad.

Auriferous quartz reefs and veins in the Dharwar rocks of the Raichur Doab have long been noted as evidenced by numerous scattered old gold-workings. The Geological Survey of H.E.H. the Nizam's Government directed their attention to this occurrence with a view to obtain an intimate knowledge of the geology of the area from an economic point of view.

The paper gives a summary of the salient geological factors bearing on the occurrence of gold in relation to the hornblende schists and the associated gneisses. The peripheral distribution of the old gold-workings in the schists in proximity to the gneisses, the blue quartz reefs and their relation to the Dharwar schists and to the gneisses, especially at their contact with the schists, are discussed.

28. The manufacture of refractories from Indian magnesite.

H. K. Mitra, Jamshedpur.

Deposits of very pure magnesite found in the Mysore State and owned by the Tata Iron and Steel Company are used in the manufacture of refractories at Jamshedpur. The two forms in which this refractory material is used are (1) 'pea' size magnesite, and (2) brick. The first stage in the manufacture of either of these varieties is the 'dead-burning' of the raw magnesite. The extreme purity of the Indian magnesite compared to that of Austria, which at one time was the only source of magnesite supply, makes the 'dead-burning' of the former difficult. Technical details are given to show how this has been overcome. The 'dead-burning' is accomplished in one process, without any preliminary calcination, in a specially designed gas kiln at a temperature of 1650°C. The dead-burned material is then crushed and screened to produce 'peas' or else pulverised to a fine powder and molded into brick. The bricks are burned in a rectangular down draft kiln, along with chrome brick. Physical, chemical, and microscopic tests of the magnesite brick are given.

The problem of recovery of carbon dioxide is also discussed.

Section of Medical and Veterinary Research.

President :—Lt.-Col. S. S. Sokhey, M.A., M.D., I.M.S.

Presidential Address.

The Relation of Research to Teaching in Medical Schools.

You must have seen by now the appeal issued by some prominent men in the country for funds for establishing an Indian Institute for Medical Research. The appeal says 'Our country......is woefully behind other civilized countries in the pursuit of medical research and in the application of knowledge to the vital problems of raising the standard of the health and efficiency of its people'. If we leave out of consideration for the moment the great work of the Indian Research Fund Association, we cannot escape the fact that medicine in India is not productive in the sense that, for example, physics and chemistry are. These sciences have produced first class workers who are making noteworthy contributions to the world fund of knowledge, but medicine is still largely barren in so far as the medical schools of the country are concerned. Taken on a lower plane, schools are not even producing, in any appreciable numbers, men with a modicum of scientific outlook and habits of serious application such as could usefully be associated with trained investigators. The Indian Research Fund Association, in its task of tackling some of the immediate health problems of India, finds it difficult, or should I say impossible, to get suitably trained men from our medical schools for its investigations. Some teachers explain this lack by the assertion that research and training of research workers have nothing to do with them as teachers and practitioners of medicine. Such a function, in their opinion, should be discharged by special institutes of research. It is assumed that research is a special subject or a special mental discipline which does not concern a practitioner of medicine. This view-point betrays a lack of understanding of the scientific spirit of medicine, and treats medicine as an empiricism. It is doubtful if such a view-point is any more successful in the sphere which the practitioner teacher regards as his very own, that is, the alleviation of suffering of the sick, than it is in the training of medical students.

I think the conclusion is inescapable that medical education and medical practice are not in a healthy state. So far we have found a scapegoat ready at hand and have been content to shift the blame to other shoulders. Now, in the near future, great administrative changes are foreshadowed and, whatever their nature, one thing is certain that the responsibility for the well-being of medical education and medical relief will fall more and more on our shoulders. It is, therefore, imperative for us to address ourselves to the problem. The subject of the teaching of medicine as a science has engaged the earnest attention of educationists in America and Europe for the last thirty years or so. Very rich and very valuable literature on the subject has appeared with which most of you must be acquainted. It is our duty now to view the American and European experience in relation to our own situation and come to some clear understanding as to what requires to be done. Clear concepts on the subject will help us to avoid making mistakes in our new ventures in medical education. So far the growth of medical education in the country does not seem to have taken place according to any logically thought out plan; it appears rather to have been conditioned by the exigencies of medical relief and administrative convenience of the moment.

Economic factors are undoubtedly decisive. But it is desirable to consider the basic demands and needs of medical education independently of these factors, so that when in practice we have to make compromises, forced on us by the economic conditions of the country, the compromises will not work out to the detriment of the future progress of medical education. A clear-cut and uncompromising statement of the basic needs of medical education will also be of help to those with authority to act in the matter. Such a statement indicating the very minimum that must be undertaken immediately can usefully be prepared only by a committee of the leading teachers of medicine and men prominent in the world of science. And, I trust, the task will be essayed before long. In the meantime, I am taking the liberty of drawing your attention to some of the salient features of the problem.

Medicine a Science.

Before I proceed further, reference must be made to another phase of the problem. During recent years, with the rising tide of nationalism in the country, demand has been made for the encouragement of study of indigenous systems of medicine, and in two provinces Unani and Ayurvedic medical schools and hospitals have actually been started. Such demands and their acceptance can arise only from an utter lack of realization that medicine has attained the status of a science; it has made very great advances by the study of disease by scientific methods. Accurate measurement and planned and reasoned experiments are its principal tools to-day like those of any other department of science. And just as in the domain of a science like chemistry there cannot be different systems of chemistry, similarly there can be no systems of medicine, but only the science of medicine. Partly the confusion is due to the loose use of the term 'western system of medicine' when actually the science of medicine is meant. Pre-scientific systems were based, for lack of adequate knowledge, on doctrines now demonstrated to be false, and what remains of those systems which may have some value are a number of drugs. Obviously the uncritical use of a set of drugs does not and cannot make a system of medicine, since scientific medicine does not debar the use of any agents for therapeutic purposes but merely insists that only those agents be used whose worth has been proved by critical experiment. The only case that could be made out would be for the critical study of drugs produced in the country. And the proper place for such a study would be scientific laboratories and not Unani and Ayurvedic hospitals conducted by men quite innocent of scientific outlook and scientific training. Such investigations are already being made by a small band of very able workers, but this work could very well be extended as the number of drugs to be dealt with is very large. The creation, by Provincial Governments, of research departments for the study of indigenous drugs would insure against the wasteful expenditure likely to be involved in the establishment and maintenance of more Ayurvedic and Unani institutions.

It is our duty to give the country a lead in this matter. I am afraid, so far, not only have no adequate steps been taken to better inform the public, but the ill-informed demand has actually even been supported by some prominent members of the medical profession. Not very long ago the president of an important medical conference made an impassioned speech advocating the study of indigenous systems of medicine, and called upon the State to subsidize such studies by the establishment and maintenance of Ayurvedic and Unani medical schools and hospitals. Even when this course is urged, as it sometimes is, to remedy the obvious shortage of medical men in the country, the recommendation is not sound. The problem of shortage there is and it has to be met, but all steps taken should ultimately lead to the spread of scientific medicine. Suitable arrangements can be suggested only on the basis of an exhaustive survey and such a survey must be made. Organization of mobile dispensaries and training large bodies of health visitors would be some of the necessary steps.

MEDICAL EDUCATION.

The lack of medical research and research workers that we all deplore and which some of us are inclined to attribute to the lack of research institutes in the country can, I think, be more accurately traced to the prevailing aims and methods of medical education.

The medical schools of the country are still of the 'clinical type' and have only superficially been affected by the recent evolution of medicine. They have aimed in the past and still aim at producing good 'practical doctors'—men who can be trusted to recognize by rough and ready means the main categories of disease conditions as demonstrated to them by their teachers and to carry out treatment by standard methods taught to them, and, in the case of failure of orthodox remedies, to make hit or miss trials on the basis of temptingly written circulars of commercial drug houses. The methods of teaching medicine are still largely didactic and attempt is made to impart the maximum amount of information during the few years the student can spend at a medical school. His training does not give him a scientific outlook and he remains untrained in scientific methods of attacking disease conditions. However necessary it may have been in the past to produce practitioners on these lines, it is obvious we must take early steps to produce more highly trained workers if we are to be in a position to tackle successfully our own problems and to add to the general fund of knowledge. There has been an easy going dependence on the basic work done abroad. This spirit is both futile and demoralizing. The very basis of ability to use knowledge is to know its limitations and these can only be realized if every one engaged in the practical use of knowledge is possessed of a critical attitude and is habituated to making accurate observations. Medical education as at present conducted does not produce these desired qualities. We must see the connection between bad education and the badly trained. And I venture to suggest that the department of studies which is most at fault is clinical work.

CLINICAL STUDIES.

The average student comes to a medical school to be made into a physician, and though he undergoes training in physiology, biochemistry, and pathology, his mind is fixed on his clinical studies and when he reaches this section of his studies he believes he has arrived at the most important part of his work. Naturally the outlook and methods of clinical instruction have the most profound effect on his future as a medical man.

His clinical teachers are invariably busy practitioners who spare a few hours from their private work during the day, come to the hospital, go over their cases as well as they can, and give what little teaching is possible in the short time at their disposal. Though clinical medicine has been enriched by the medical sciences during the last fifty years and the elucidation of a case has become a complex business requiring the aid of chemistry, bacteriology, pathology, immunology, and radiology, the teachers still try to diagnose their cases on the basis of symptoms and obvious physical indications. True, they send specimens to the hospital laboratories to be examined by men who have no interest in the cases, but this is done merely to make the business of diagnosis easier. The laboratory examinations are not systematically used to demonstrate the nature and extent of the functional or structural change of the diseased body as compared with the normal body. Diseases are presented to students not as departures from the normal but as eternal verities to be spotted quickly by various dodges and to be treated by various means. It is tacitly understood that if a given medicine or means has relieved the patient of his complaint there is nothing more to be said or done by the physician or the student, or if a given medicament has not done what was expected of it then there are plenty of alternatives so considerately provided by commercial drug houses to try. If the problem is a surgical one the thing is easier still: exploratory operations are readily resorted to and the desired cure is attempted by tentative operations on far too superficially studied cases.

MEDICINE PRESENTED AS AN EMPIRICISM.

Medicine then is being presented to the student as an empirical art. Until very recent times when most of the present teachers were students themselves, it was still fashionable to so designate medicine. Their own training was undertaken by men who, in the vast majority, were merely successful practitioners and who did not hold their teaching positions on the strength of their original contributions to knowledge. Whatever may have been the triumphs of empiricism in the past, it cannot be depended on for further advances of knowledge because the problems that were capable of solution by superficial observation have already been attacked and those that remain require much deeper study.

Further it has been abundantly demonstrated that disease conditions are amenable to scientific study and the application of scientific methods in the elucidation of disease has yielded a rich harvest of knowledge. From the point of view of the student the question is vital; empiricism can never be a mental discipline. If a student is to be enabled to extend human knowledge he must be given a thorough grounding in the intellectual technique of inductive science. If an attempt is made to teach the student by culling and arranging for him useful bits of knowledge, he is likely to be a passive agent in the process. Under the conditions he would leave the medical school without the necessary equipment to enlarge his knowledge. He would always be a prey to dogmatism.

CLINICAL SCIENCE.

The teaching of clinical subjects, then, is the weakest spot in the present organizations of medical education. This state of affairs has been suffered to continue because there has been lack of clear understanding of the formative value of clinical medicine as a science. Not only the attitude of the practitioner of medicine but also, strangely enough, that of the laboratory worker has clouded the issue. There has been a disposition to consider only laboratory work as scientific; even to-day the average laboratory worker is loath to admit clinical work to the dignity of a scientific endeavour. This attitude is injurious both to medicine and to medical education. In this connection I cannot do better than quote to you from a recent stirring address by Sir Thomas Lewis: 'The central and unique studies of clinical science, most fundamental of all studies pertaining to the practice of medicine, are those which deal with living men. But these cannot be divorced either from anatomy or from experimental work on animals........It is quite necessary to the proper progress of the clinical branches of study that they should be most strongly linked with physiology, with morbid anatomy, and with what has been called experimental pathology. The linkage can be an enduring one only if clinical science continues to command opportunities of studying both dead bodies and living animals.'

'It is essential that those who have held charge of patients and have studied phenomena in the living should themselves, and not through skilled deputies, explore the tissue changes which may underlie the disturbed function; for while the skilled deputy may more accurately describe and name those changes in the tissues upon which he chances, he cannot enjoy either full opportunity or the full inspiration to correlate function and structure. It is by these correlations that the meanings of many manifestations during life are explained; it is by correlation rather than by the simple study of the cadaver that the meaning of illness and the cause of death are often and usually to be explained. It is essential that those who in studying human patients perceive opportunities of putting questions to the test of animal experiments should themselves engage in such work; that correlation should not be left to the chance meeting and union of clinical and laboratory studies; that the spirit which moved the original enquiry should live, vitalizing and directing the whole work in its progress along a broad path towards a practical goal. To divide or attempt to divide medical research into ward research and laboratory research is narrow and mischievous; it is a profound error to believe that there is any essential difference in general method, however different may be the technique.'

RESEARCH.

We may take it then that when clinical work is undertaken as scientific work, each new patient becomes a problem for investigation, and can be most effectively used for giving the medical student a thorough grounding in the scientific methods of investigation and habits of application. Further clinical work so organized would produce new knowledge; not only would clinicians be constantly enriching the diagnostic and the therapeutic work by the application of new knowledge of anatomy, physiology, pathology, and biochemistry, but when suitable opportunities occur would actually be contributing original knowledge to these sciences.

From the point of view of the student the problem of research has a very great significance. In an atmosphere where active research is proceeding he sees knowledge in its growth and is stimulated by the intellectual standards that underlie such work. Knowledge is not presented to him as something final or flawless but as an approximation with numerous shortcomings. He is encouraged to test the fact he learns from books or from teachers by first-hand examination. Thus he is trained in the spirit and methods of science.

So far I have stressed research in clinical departments only, not because other departments of a medical school do not matter, but because there is little or no difference of opinion regarding them and a great deal has already been done towards the proper organization of the departments of physiology, biochemistry, and pathology; but because the clinical departments, though of the greatest formative value to the student, are still being run on essentially a non-scientific basis.

We may say then that suitable medical education can be imparted only in an atmosphere of active research by those who themselves are actually engaged in research. Such an education is not needed solely for the production of trained research workers, but is essential even for the production of practitioners of medicine who would undertake the care of the sick with watchful intelligence rather than by rule of thumb.

If we are to remedy the unsatisfactory state of affairs, it is obvious that we should organize the teaching departments of all our medical schools of the university standing under men who are fully trained in the methods of science and have distinguished themselves by their contributions to original knowledge. The number of such men in this country is small but the teaching schools should have the prior claim on the few that are available and others that can be induced to come to India. The establishment of research institutes separately from the teaching colleges does not help the situation directly, and actually may make the situation worse by taking away the few workers who may be available to spheres of activity where their work cannot have the same energizing influence. Research institutes so founded would offer facilities for post-graduate training, but post-graduate training can hardly undo the damage done by faulty under-graduate training. It is much the best plan to handle the training of a medical student properly from the very start, rather than try to rectify its defects among a few students by the doubtful expedient of post-graduate training.

The organization of clinical studies, as I have indicated, is our main difficulty. There is little doubt that the teaching of modern medicine cannot adequately be carried out by busy practitioners, no matter how capable. The work requires not only special training and special aptitude but also the whole time of the teachers. They must devote themselves heart and soul to their work. But it is not enough to merely employ whole-time teachers, the work must be made attractive for them by the provision of adequate facilities for their work, abundant material, suitable laboratories, and necessary assistance. It is important that the assistants must be men of high calibre to be able to take up part of the teaching work and care of patients and thereby produce leisure for all to engage in research work.

If we are to expect these men to devote themselves heart and soul to their work we must relieve them of all financial worries by giving them good living salaries. These salaries do not need to be high as a counter attraction to the large incomes which successful practitioners may be able to command, but must be adequate to meet the real needs of the teacher and his family. They should be calculated on the same basis as the salaries of professors of other sciences in a university.

Two objections are usually raised to whole-time clinical work. It is asserted that the types of cases that a physician has to deal with in a hospital do not give a true picture of disease conditions, that diseases only in advanced or chronic condition are seen in hospitals, and that it is necessary for a physician to engage in private practice and see all sorts of cases at all stages of development. The second objection is that well-to-do patients are prevented from availing themselves of the services of eminent physicians. The first objection is losing its cogency every day; even in India the hospitals are becoming more and more popular and large attendance at out-patients' departments should provide enough facilities for the selection of different types of cases specially needed by a worker. Also prohibition of private work by a whole-time worker does not mean that he is debarred from seeing cases outside the hospital; all that is stipulated is that he should not see patients for a monetary consideration. The second objection is easy to meet, more so now than ever before. It is being universally recognized that the care of sick in a well-conducted hospital is better organized than what can be achieved by private arrangements. People are losing their prejudice against hospitals and are actually demanding that room should be found in hospitals for people who can afford to pay. When a clinic of the type I have in mind is organized, arrangements should of course be made for accommodation for paying patients. The moneys so received would add to the resources of the clinic.

I am aware of the fact that running of clinics on this basis is a costly affair, and we may not be able to command enough funds for the purpose for years. But the need is urgent and if we are convinced that something of the sort is needed, we shall put forward the necessary effort to achieve our object. The very minimum that must be aimed at in the very immediate future in each university is one full-time professor of medicine, one of surgery, with at least two associate professors each, and the necessary junior staff of a mental calibre akin to that of the professor so that the whole team can work as colleagues. Along with this, each such clinic will need well-equipped students' laboratories and ward laboratories in which routine microscopic, bacteriological, chemical, radiographic, and electrical work can be carried out. In addition to these, special laboratories for research work by the whole-time staff will be needed.

PRE-CLINICAL STUDIES.

The principle of the whole-time teachers has been universally accepted as regards the pre-clinical sciences and all the university medical schools have whole-time teachers of anatomy, physiology, and pathology. Though the principle of whole-time work has been accepted it seems to me that it has not been logically worked out. The professors are not provided with adequate assistance, or with adequate laboratory facilities. Most often a whole-time man has to undertake single-handed the whole responsibility of teaching and the administration of his department. He is called upon to deliver numerous lectures on all the various aspects of his subject, to arrange and supervise the practical work of the students, and to take part in examinations, besides attending to all the administrative details of his department. The work under the conditions leaves little leisure for original investigation.

It is essential then that each professor should have three or four whole-time assistants, men of capacity and of distinction in their subjects. Owing to the vastness of the subjects to be taught it is impossible for one man to deal adequately and efficiently with every part of any one of them. Hence the necessity for him to find in assistants men whose knowledge will complete his. And, moreover, as no mind works its best in a vacuum, the professor must have men of standing and learning in his department, with whom he can discuss and thus derive the necessary stimulus for good work on his part and theirs. The teaching and administrative work of the department should be divided up and thus leisure created for all to engage in research work.

With some such staff the departments would be in a position to give the student more than the minimum required for the examinations. This is a matter of extreme importance for medical schools of a university standing. They cannot concern themselves solely with imparting just the minimum amount of knowledge so that men may pass certain examinations. The primary aim of a university must be to further scholarship, to create an atmosphere and give opportunities which will enable the better type of student to develop to his highest. To attain this highly desirable object the medical colleges must offer something more than the minimum needed for examinations in each of the pre-clinical sciences. One of the plans to achieve this is to make two afternoons free every week. The mediocre student would thereby have time to go over the work already done, and the better type of student would utilize the free afternoons in taking more special work relating to the subjects being dealt with in the class work. This special work might take the form of voluntary courses given during these afternoons by the different members of the staff who have made a special study of certain aspects of the subject. Take for example, physiology; the regular work will concern itself with physiology in its broad aspects and will require the student to perform a series of elementary experiments intended to familiarize him with the methods which physiology employs to acquire knowledge and which will demonstrate to him the fundamental concepts of physiology, while the special courses will deal with some aspects of the subjects in greater detail like metabolism and nutrition, the endocrine glands, and so on. In the department of anatomy, comparative anatomy, embryology, physical anthropology might be cited as examples of special courses.

POST-GRADUATE TRAINING.

Post-graduate training in medicine is from our point of view a most important side of medical education. Medical science is very vast and growing more so every day. The average under-graduate student can, at most, devote only a limited time to its study. In the five years that are usually devoted to it the teachers can only impart the methods and spirit of medicine and the more salient details of fundamental importance. Either the imparting or the acquisition of an encyclopædic knowledge of medicine is out of the question. Good schools try and give the student a thorough grounding in the fundamentals and set him on the road to teach himself as he gets along with his medical work. But a medical school of the university standing must also produce teachers and men of higher learning. In addition, the presence in the various departments of a medical school of men devoting their time to higher study is essential for the creation of the right type of atmosphere to inspire the under-graduate student to take more than an artisan's view towards his training. Therefore, each medical school must provide facilities for those young graduates who wish to devote or can be induced to devote more prolonged periods to the further study of medicine. These facilities must be of a type to give full scope to the student to conduct investigations himself under the supervision of professors.

No adequately organized facilities exist at present in our schools. Short refresher courses arranged for old graduates or even courses of short duration in subjects not dealt with in under-graduate studies do not serve the purpose of post-graduate education. Ambitious and well-to-do students go abroad in search of suitable facilities, but such facilities in foreign countries are difficult to obtain and are becoming more so every day. Even at the best of times the majority of such expensive trips abroad have been economically wasteful; they are undertaken at a period when the students are still immature and are not well fitted to derive the maximum benefit from contact with foreign workers. Very often these journeys are undertaken merely to obtain medical diplomas of doubtful value.

Post-graduate teaching should then be organized in medical schools to give selected students who are willing to spend more time on further study of medicine after graduation, suitable facilities to acquire an intimate knowledge of the subjects of their choice under the guidance and supervision of professors who themselves are engaged in original work. Students would either collaborate with their professors in the investigations being conducted in their departments or would engage in investigations of their own. Such studies could easily be arranged as work for higher degrees and students called upon to devote at least three years to these studies.

If we are going to ask our best men to spend long periods on strenuous work after their graduation, we must respect their effort and make it attractive for them. Firstly we should give scholarship to all such students who take up higher work. In a poor country this is the only way to make it possible for men to undertake higher studies. Secondly we should select our future teachers from among them. We should do more; we should provide fellowships to those of our men who give promise of real ability to go abroad for working in laboratories and clinics of distinguished workers.

The relationship between medical research and medical education is an intimate one. For the effective prosecution of research to solve the health problems of the country large numbers of competent and well-trained men are needed, and it is now generally agreed that the atmosphere of active scientific inquiry is essential for efficient training. Medical research then should primarily be organized in medical schools. Special research institutions organized to meet some special needs would leave the educational problem unaffected.

Section of Medical and Veterinary Research.

Abstracts.

1. A comparison of the standard lactose bile-salt neutral red broth with the M.B., B.C.P. medium of Dominick-Lauter, in water analysis.

T. N. S. Raghavachari *and* P. V. Sitarama Ayyar, Madras.

Dominick and Lauter of Washington, D.C., claimed certain definite advantages for their new medium (Methylene-blue Brom-Cresol-Purple Broth), in differentiating bacteria of the Coli-ærogenes group found in water. An early sharp and direct colour change from blue to yellow in 16–24 hours, due particularly to the *B. Coli*, together with a complete inhibition of symbiotic lactose fermenters constitute the main advantages.

As the medium appeared to offer distinct advantages, a comparison was made by using the new medium along with the authors' routine standard Lactose broth for the preliminary enrichment, subcultures being made on Rebipel agar. Samples of water from various sources were thus tested.

The authors' results have failed to substantiate the claims made by the sponsors. Their findings show that: (*a*) The standard Lactose broth yields a large number of presumptive positives. (*b*) In the confirmatory tests, the standard Lactose broth cultures were found to be superior to the other in that only *one* out of 45 presumptive positives failed to yield Lactose fermenters while *four* out of 42 failed in the new medium. (*c*) Again, 65·2 per cent. of the organisms isolated from the standard broth and only 37·7 per cent. of those from the M.B., B.C.P. medium were *B. Coli* (i.e. MR+Indol+type). (*d*) Contrary to the sponsor's claims, 42·4 per cent. of the organisms isolated from the M.B., B.C.P. medium and only 15·8 per cent. from the standard broth belonged to the ærogenes group (i.e. VP+Citrate+). The new medium is *not* therefore specific for *B. Coli* in 24 hours. (*e*) The intermediates (i.e. MR+Indol−) by both methods were approximately the same in number (19 per cent. for the standard Lactose and 19·9 per cent. for the new medium). (*f*) On the basis of colour change from blue to yellow in 24 hours or less in the new medium and the production of acid and gas in the standard broth, as the sole indication for the presence of the Coli-ærogenes group in any water, the standard broth appears to be still the superior. Thus, in 51 comparative tests, the new medium was more delicate only in 10, equal in 16, and less delicate in 25 cases as compared with the standard medium.

Conclusion.—The Dominick-Lauter broth does not offer any special advantages over the standard Rebipel broth in routine water analyses under the conditions of the authors' tests.

2. A fallacy in experiments on the effect of hydrogen-ion concentration on bacteriophagy.

N. H. Nanavati, Bombay.

A considerable amount of work has been done in order to find out the most suitable reaction (pH) for the action of bacteriophage, but no conclusive evidence in favour of any particular pH has been obtained.

In almost all the experiments, the procedure has been to arrange a series of test-tubes of the same medium containing identical concentrations of bacteria and bacteriophage, but the reaction of the medium adjusted to different pH values in the different tubes.

It is not generally realized that in the course of an experiment the reaction of an individual tube is continuously changing, so that the reaction at the time of lysis may be very different from the initial reaction. A device to keep the reaction of the medium constant during bacterial growth would solve the difficulty.

3. Observations on the combined method of Clot Culture and Widal Reaction, with a preliminary note on the significance of 'small-flaking' or 'O' agglutinins in typhoid fever.

D. W. Soman, Bombay.

The first part of the paper summarizes the various advantages claimed by combining the two methods in the investigation of typhoid fever, for instance, Widal Test and Clot Culture from one single sample of blood, taken during any period of the course of infection. The method is fully described and more than 400 observations recorded.

The second part deals first with a brief history of 'O' agglutinins and the actual technique of demonstrating them. Fifty cases of typhoid fever are briefly recorded in the light of their clinical course, approximate day of infection, day of Clot Culture and the customary Widal with a special 'O' agglutination test. Out of these fifty cases thirty-eight recovered and twelve proved fatal. From the above data collected, it has been possible to study the behaviour of 'O' agglutinins in typhoid fever, on the following points :—

(*a*) Earliest appearance.
(*b*) Earliest disappearance.
(*c*) Longest period at which they are observed (Hospital patients).
(*d*) Diagnostic level of 'O' agglutinins in typhoid fever in Bombay.
(*e*) Their significance in Sero-prognosis.

4. On the application of Helmholtz principle in the tracing of genesis of tetanus curves with vibrating reed.

N. M. Basu, Calcutta.

In tracing genesis of tetanus curves with vibrating reed it was noticed that alternate make and break of the reed cause unequal contractions. If the make shocks are eliminated by moving away the secondary coil, the curves due to break shocks alone are equal but become very small. It was, therefore, suggested that the make and break shocks may be equalized by the provision of a path for the break extra-current in the primary circuit. Curves were taken accordingly and it was found that the make and break contractions have become equal.

5. On the action of urea-stibamine on frog's heart.

N. M. Basu, Calcutta.

The effects of perfusion of urea-stibamine solution in Ringer's fluid on frog's heart were studied, care being taken to maintain the fluid pressure at a constant heat. It was found that at a concentration of 0·8 mg.% urea-stibamine causes depression and slowing of the heart-beat and at double the concentration the heart-beats were not only depressed and slowed but became irregular within 30 minutes. The weight of the frogs experimented upon varied from 80 to 105 gms. In the case of lower concentration repetition of the perfusion causes slowing but not depression.

6. On the effects of histamine on frog's heart.

N. M. Basu, Calcutta.

The effects of histamine on frog's heart were studied in the same way as urea-stibamine. It was noticed that at a concentration of about 0·00002% the heart-beats become augmented but slowed slightly after about 5 minutes' perfusion, but if the perfusion continues for more than 20 minutes the beats are slowed and decreased in force. At a higher concentration the augmentation is almost immediate and marked and if the perfusion continues the heart becomes considerably slowed and beats get irregular. If the concentration be not very high irregularity disappears in the course of perfusion.

7. On the effects of perfusion of frog's heart by a kaviraji heart-stimulant, named 'Brihad Kasturi Bhusan'.

N. M. Basu, Calcutta.

The effects of perfusion of this drug on frog's heart were studied in the same way as in the case of histamine. It was found that at the concentration of 0·005% there is marked augmentation and acceleration which are maintained for a long time. At the concentration of 6·5 to 7·5 mgms. per 100 c.c. Ringer's fluid, the augmentation and acceleration that were noticed very shortly after the perfusion commenced diminished a little but were maintained at that level for a long time. At a higher concentration, i.e. 14 mgms. per 100 c.c. Ringer's fluid there were augmentation and flowing for a short while. The force of the heart-beat then gradually decreased till the heart stopped. Perfusion with Ringer restored the heart-beats and made them fast.

8. Studies in gastric secretion with special reference to variations in gastric acidity.

S. L. Bhatia, Bombay.

After a brief historical review of the methods employed to obtain gastric secretion, the experimental work in the Physiological Laboratory, Grant Medical College, is described, which consisted in: (*a*) Examination of the fasting juice. (*b*) Response of the secretion to a standard test meal.

A new standard test meal from rice is described and its advantages over the other test meals explained.

Gastric analysis was carried out according to the fractional method of Rehfuss, and the subjects of the experiments were normal adult Indians. Observations show that the free HCl in the fasting juice in a great many normal persons is very low, and in some it is completely absent. After the test meal the acid curve rises, reaching a maximum in 1 to 1½ hours. The height reached varies considerably and is usually within 0·16% and 0·22% HCl.

The stomach empties also comparatively rapidly (in 1 to 1½ hours). Clinically the rise in gastric acidity after a test meal is the important point to note. The presence or absence of free HCl in the fasting juice alone is of no practical significance.

9. The use of the Galvanometer for investigating normal and pathological conditions of neuromuscular structures of the human body and particularly of the heart.

J. N. Maitra, Calcutta.

Animal Electricity.

Early History:—Galvani's Experiments on liberation of electric energy from frog's muscles ready for being cooked. Volta's contention of dissimilar metals being essential in the production of electricity.

The heart as it contracts produces electric currents and differences of potential thus produced can be measured by a Galvanometer.

Principle of a Galvanometer :—

(1) D'Arsenoval Type.
(2) Magnetic Needle Type.

Electric currents of very low voltage are produced and the resulting oscillations of a silver quartz fibre photographed. Curves thus obtained give us information regarding abnormalities in the focus of origin of the stimulus to contraction and in the path of transmission of the stimulus.

The capillary Electrometer was the original instrument. Einthovan's string Galvanometer is the final and most perfect instrument. There are two forms of Electrocardiograph on the market to-day, one form relying upon magnification of the movements of the shadow of a very fine fibre and the other form relying upon the magnification of the varying heart voltage by means of wireless valves and movements of a beam of light reflected from a mirror fixed to a magnetic needle.

The tracings obtained by these two methods show considerable difference in pathological cases. The former has been in use for about 20 years and has proved its worth. Owing to the relatively greater weight of the structure it may introduce alteration in the tracings due to momentum.

10. Aketotic alkali reserve and its significance in diabetic coma.

N. H. Nanavati, Bombay.

By 'aketotic alkali reserve' is meant the plasma bicarbonate as determined *plus* an amount of plasma bicarbonate corresponding to the amount of keto-acids in blood ; in other words it is the alkali reserve *sine* the effect of fixation of base by keto-acids.

Starr and Fitz in the course of an investigation on diabetic coma discovered that when the diminution of alkali reserve was out of proportion to the degree of ketosis, i.e. when the 'aketotic alkali reserve' was low, the coma tended to be more severe and less amenable to treatment. The finding of Starr and Fitz is confirmed in three cases.

Doubts regarding the rôle of ketosis in the causation of acidæmia are discussed.

11. The pharmacological action of 'Abrine'—a non-bitter alkaloid obtained from the scarlet seeds of *Abrus precatorius*.

P. C. Ray, A. C. Roy, *and* S. A. Hasib.

Abrine is one of the active principles isolated from the scarlet seeds of *Abrus precatorius*. The plant is a twining slender perennial one of the Leguminosæ order and grows wild all over India from the Himalayas to Ceylon. The roots, the leaves, and the seeds have been recommended for use in various diseases by Sushruta and other Sanskrit writers. The seeds are highly poisonous and are used for suicidal and homicidal purposes as well as for poisoning cattle. Dr. L. A. Waddel separated a toxalbumen called 'Abrin' in 1884. Very recently Ghatak (*J.I.C.S.*, Vol. IX, p. 383) reported the presence of a non-bitter alkaloid 'Abrine' and a glucoside 'Abraline'. This alkaloid has been isolated by the authors and found to be altogether different from the toxalbumen as regards its chemical and pharmacological actions. Its melting point is 295°C. and it does not respond to reactions of proteins.

The toxalbumen is reported to be poisonous from 1/2000 to 1/1000 mg. per kilogram body weight while this alkaloid failed to produce any unusual or poisonous symptoms even when 50 mg. per kilo were injected subcutaneously into white rats. It does not produce any inflammation of the cornea or irritation at the site of inoculation like the toxalbumen. It has a distinct stimulant action on respiration and on Vagus and the cardiac muscle both in frogs and mammals. In small doses it increases the functional activity of the striped muscles and stimulates the plain muscles of blood vessels, intestine and uterus. But in slightly larger doses it depresses the Vagus, heart, and all forms of muscle-tissue.

12. The pharmacological action of ‘Thevetoxin’—a second glucoside isolated from the seeds of *Thevetia neriifolia* (yellow oleander).

P. C. Ray, A. C. Roy, *and* S. A. Hasib.

Thevetia neriifolia is the yellow oleander found commonly on the plains all over India. It belongs to the natural order Apocynacæ. The seeds are known to be highly poisonous and are used for suicidal and homicidal purposes as well as for abortion. Devrij was the first to obtain a crystalline glucoside from the kernel of the seeds which was named ‘Thevetin’.

Chopra and Mukherjee (*Proc. Ind. Sci. Congress*, 1933) have tested its pharmacological action and found it to resemble in many respects the drugs of the digitalis group. A second glucoside has been isolated by the authors and may be called ‘Thevetoxin’. It differs from ‘Thevetin’ in having a lower melting point and yielding a different product on hydrolysis. It melts at 178°-179°C., while the former at 189°-190°C. ‘Thevetin’ is freely soluble in alcohol and chloroform but sparingly soluble in cold water and insoluble in ether, petroleum ether, etc., whereas ‘Thevetoxin’ is freely soluble in cold water and alcohol but insoluble in ether and chloroform.

‘Thevetoxin’ does not appear to be so poisonous as ‘Thevetin’. The M.L.D. of the latter is 0·14 Mg. per kilogram body weight of cats, while with the former no poisonous symptoms appeared even after a dose of 114 Mg. per kilo in white rats. But the M.L.D. of the latter varies from 0·15 Mg. to 0·3 Mg. per kilo of frog, while that of the former varies from 0·025 to 0·05 Mg. per kilo of frog and the former has a more powerful pharmacological action. It distinctly stimulates the respiration and plain muscles of blood vessels, intestines and uterus. It produces a definite rise in blood-pressure and has a stimulant action on the vagus and heart muscle like the drugs of the digitalis group. The paradoxical results in the case of white rats may be due to increased tolerance of the drug by the animals or to some other factor.

13. Treatment of leprosy by the *Hydnocarpus wightiana* Oil.

Z. Andre *and* Labernadie, Pondicherry.

If the results obtained by the Chaulmoogra oil in the treatment of leprosy vary very much, it is particularly because the practitioners do not have always a pure, fresh, and total oil and also because the absorption of it per os and the sub-cutaneous injections are indirect ways.

The connections of the Hansen bacilli to the cells of the reticular-endothelial system are well known. It is to these cells that the remedy should be applied directly as far as possible.

In this way, the authors hope for more rapid action and more durable results.

Description of the technique. Results obtained.

14. An observation on Benedict and Fehling titrations and detection of their end-point.

K. N. Bagchi, Patna.

In a previous communication (*Patna Journal of Medicine,* 1932, VII, 3) the use of methylene blue as an internal indicator in estimating reducing sugars in urine by Fehling's method was described. The Benedict method of estimation of sugar is much more reliable than Fehling's when the quantity of reducing sugar is low (below 1%) but in highly coloured samples of urine containing excess of urates, the end-point in Benedict titration is not sharp and the result is never accurate. Although the change of colour from blue to milky white in the Benedict reagent indicates the end-point and thus serves the purpose of an internal indicator, it is not always safe to depend on this change alone when dealing with a coloured sample. The Benedict method of titration can be considerably improved by using 3–5 drops of 1% solution of methylene blue as an internal indicator exactly in the same way as in the Fehling titration originally described by Lane and Eynon and the end-point is very accurately determined giving a constant result.

The Benedict reagent is not reduced by uric acid or urates of urine but it is easily reduced by other reducing non-sugars of urine, notably the mucin, reported in the *Journ. of the Ind. Med. Assocn.* (Vol. II, 1933, p. 440). The urates of urine also act upon copper sulphate and form a brownish or bluish-white precipitate of copper urate which is often mistaken for the precipitate produced by traces of reducing sugars. Under these circumstances, the Benedict reagent is as bad as the much condemned Fehling for qualitative test for sugars in urine. The separation of all reducing non-sugars by means of normal lead acetate and Pot. oxalate is therefore essential both for the Benedict and Fehling tests and when they are removed both the methods are equally good.

15. Further observations on the chemistry of the oxytocic hormone of the pituitary gland.

B. C. Guha *and* N. B. Das.

Chemical studies on the oxytocic principle of the posterior lobe of the pituitary gland have been continued. The hormone is not adsorbed by alumina at pH 5·0. In the Kossel-Kutscher procedure of silver nitrate-baryta fractionation, the hormone comes down at pH 6·0. With phosphotungstic acid it is precipitated at pH 5·0 and a considerable concentration is effected at the same time. Ultra-violet irradiation destroys the principle.

16. The rationale and the results of the treatment of pulmonary tuberculosis by Phrenicectomy—an analysis of 286 cases.

M. Kesava Pai, K. Vasudeva Rao, K. S. Sanjivi, *and*
K. Venkat Rao, Madras.

By actual measurements and by clinical results, it has been proved that phrenic evulsion benefits both apical and basal involvement. The present series of 287 cases included both unilateral and bilateral advanced conditions with cavitation on one or both sides. The immediate results showed improvement in over 70% cases, the basal cases showing benefit in 90%. Non-tuberculous basal affections, empyema, pyo-pneumothorax, and chronic pleurisy also benefited to a considerable extent by phrenicectomy. The remote results were not so good, 50% or more dying during the first 18 months. The benefits of phrenicectomy are due more to the secondary collapse of the later periods after the operation than to the primary collapse resulting from the diaphragmatic paralysis.

17. The value of Sanocrysin treatment in pulmonary tuberculosis.

P. V. Benjamin, Madanapalle.

440 patients have been treated with Sanocrysin at the Union Mission Tuberculosis Sanatorium, Arogyavaram, Madanapalle, since the year 1925. Of these, 350 had four or more injections of Sanocrysin. A review of the results of treatment in these 350 patients is given.

The value of any special treatment in pulmonary tuberculosis is best judged by its results in the advanced cases (III stage). 264 out of the 350 patients were in the III stage of the disease. Of these, 66 per cent. improved and 36 per cent. could be discharged as clinically well.

21·7 per cent. of 143 III stage patients receiving Sanocrysin treatment along with Sanatorium routine treatment lost bacilli; while only 12·3 per cent. lost bacilli out of 423←III stage patients treated with Sanatorium routine alone, before the introduction of Sanocrysin treatment.

In 86 out of 264 patients, Sanocrysin was used combined with artificial pneumothorax, as these patients had active disease in the contralateral lung. A comparison is made with a similar group of 152 artificial pneumothorax patients, who had contralateral affection but who could not get Sanocrysin treatment. Of the first group of 86 patients, 36 per cent. became clinically well while of the second group of 152 patients, only 14·5 per cent. obtained the same result. A further comparison of these two groups with regard to disappearance of tubercle bacilli from sputum and disappearance of fever, shows that in the group which had Sanocrysin, 33·8 per cent. lost bacilli and 53·2 per cent. became free from fever; while of the other group only 16·7 per cent. lost bacilli and 22·5 per cent. got rid of fever. This shows how the introduction of Sanocrysin has improved the results of artificial pneumothorax treatment in patients having disease in contralateral lung.

18. The value of Solganol in the treatment of pulmonary tuberculosis—an analysis of 77 cases.

M. Kesava Pai, K. Vasudeva Rao, K. S. Sanjivi, *and* K. Venkat Rao, Madras.

An analysis of the treatment of 66 cases of pulmonary tuberculosis with Solganol and Solganol B and of 11 cases with Solganol-B-Oleosum is given in this paper. Solganol and Solganol B were used in doses of ·001 gramme slowly increased to ·01 gramme and Solganol-B-Oleosum intramuscularly in doses of 0·01 gramme increased to 0·4 gramme.

In 33 cases treated with less than 6 injections of Solganol, 57% benefited, 24% showing marked benefit. In 33 cases treated with more than 6 injections 69% benefited, 27% showing marked improvement; 8 cases became bacillus negative out of the series of 66 and 17 showed a decrease in the number of bacilli in the sputum. Excluding such of the cases as were simultaneously treated by artificial pneumothorax or phrenicectomy or both, it was seen that 50% cases benefited by Solganol treatment alone combined with general treatment.

Of the 11 cases treated with Solganol-B-Oleosum emulsion, 82% benefited, 55% showing marked benefit; 4 became bacillus negative and in 3 the bacilli showed a decrease.

Signs of gold poisoning and complications seem to be less frequent in Solganol treatment than in Sanocrysin treatment. Solganol-B-Oleosum appears more efficacious than the intravenous preparation.

19. A clinical analysis of 64 cases of spontaneous rupture of the lung.

M. Kesava Pai, K. Vasudeva Rao, K. S. Sanjivi, *and* K. Venkat Rao, Madras.

Spontaneous pneumothorax is more frequently met with than is commonly supposed and is often insidious in onset. The circumscribed and insidious cases are apt to be missed unless a careful physical examination is made. Rupture may take place on the side of artificial pneumothorax or in the apparently normal lung.

Spontaneous pneumothorax has been met with in 1·5% of all cases in Madras being 2½ times more frequent in males than in females. It has been most frequent between the 20th and 30th year. The rupture took place with the same frequency on the two sides. The general mortality was 71%, about 45% dying immediately after the rupture. Effusion occurred in ⅔ of the tuberculous cases, empyema resulting in ⅙ of the total number. Intermittent deflation had little effect on the prognosis. Deep mediastinal emphysema was met with in one case which proved fatal.

20. Treatment of pulmonary tuberculosis by the *Hydnocarpus wightiana* Oil.

Z. Andre, Pondicherry.

The success of pneumothorax is well known, but often an additional treatment is necessary.

Like other practitioners, the author and his associates have used gold salts. Although incontestable improvements occurred, they failed in more than one case, because several patients did not stand this remedy. They could hardly administer more than 0·1 gram, on account of the shock and sometimes of erythrodermies. It was perhaps due to the insufficiency of liver so common in our regions where diabetes is prevalent.

Since a short time, instead of sanocrysine, they are using Chaulmoogra oil (*Hydnocarpus wightiana* Oil) which, by a new method, they bring directly into contact with the pulmonary lesions.

Description of the technique. Results obtained.

21. Treatment of some pulmonary (non-tubercular) diseases by intravenous injections of Lipo Vaccines (microbes in olive oil suspension).

Andre, Labernadie, Nadessin, Pons, *and* Talec, Pondicherry.

The authors tried the injection in the blood stream of microbes suspended in olive oil (Lipo Vaccines) to avoid the shock experienced when saline suspensions were employed. Encouraging results were obtained.

Some cases of asthma were treated with Lipo Vaccines of Intestinal Germs.

22. Auto-urine therapy against asthma.

Z. Andre, Pondicherry.

The therapeutics of Asthma has been enriched during these last 10 years with new methods.

This is due to the work of Widal on anaphylaxis and colloidoclasy and to the researches of Ravaut on sensibilization and desensibilization.

It is known also that desensibilization by auto-hæmotherapy is valuable in various diseases and particularly in asthma.

Since a few years Prof. Jausion extols a new method of desensibilization: Auto-urine therapy; i.e. subcutaneous injection of one's own urine against some skin diseases.

The author and his associates have used this new method against the Asthma crises and have noted very sensible ameliorations and cures.

Description of the technique. Results obtained.

23. The Vernes Resorcin serum test for tuberculosis.

M. B. Soparkar *and* C. S. Dhilon, Bombay.

Results of Vernes tests of sera of a series of 346 hospital patients suffering from various conditions other than tuberculosis gave positive results in over 50 per cent. of cases. The test is not specific for tuberculosis.

24. Specific therapy of plague.

P. T. Patel, Bombay.

A review of treatment of plague by sera from various institutions cited below with the results :—

(*a*) Lustig's serum (Italian).
(*b*) Pasteur Institute (Yersin).
(*c*) Lister Institute.
(*d*) Bern Institute (Yersin).
(*e*) Haffkine Institute.

These results with or without control show that there is absolutely no reduction in the mortality rate, i.e. from 70 to 80%, it does not matter what serum, by what method and in what quantity is used.

Similar are the results of treatment with vaccine, bacteriophage, etc.

25. Serum therapy of plague.

B. P. B. Naidu, Bombay.

Several remedies, such as antiplague sera prepared by different methods, 'salted', 'sensitized', and 'detoxicated' plague vaccines, antipestiphage of d'Herelle and chemotherapy with well-known germicides, have all been employed in our plague hospitals for the treatment of this disease. The results, which have attended their use, have been disappointing. An antiplague serum is at present the only remedy that holds out any hope of reducing the excessively high case mortality, a fresh attempt is made at the Haffkine Institute to approach this problem.

Sheep, cattle, and buffaloes have been immunized to obtain a serum which exhibits both antibacterial and antitoxic properties. The results, which have attended their use in experimentally plague infected laboratory animals, have been so very promising that attempts at the treatment of human cases admitted to our plague hospitals were undertaken.

The first trial was made at the Isolation Hospital, Hyderabad (Deccan), in 1931, with promising results. But, as the epidemic at Hyderabad was on the wane at the time of this trial, a second trial to treat cases admitted to the Isolation Hospital, Poona, at the height of the epidemic, was made during September and October, 1933. The results of these two trials showed that in mild septiacemic and purely bubonic cases, the administration of our locally prepared serum effected a saving of 37 per cent. more lives as compared with controls of similar type. With further improvements in the preparation of the serum it is anticipated that a still larger number of lives would be saved.

26. Dogs and plague.

W. J. Webster *and* G. D. Chitre.

It has been suggested that dogs are immune to plague and might be kept in human habitations to attract plague-infected fleas and thus prevent human infection. Some experiments are detailed which indicate that dogs are not susceptible to plague but that they are not sufficiently attractive to rat fleas to produce the suggested result.

27. On the occurrence of *Schistosoma japonicum* Kasturada in India.

G. D. Bhalerao, Muktesar.

The schistosomes obtained from a pig in Calcutta have been identified as *Schistosoma japonicum*. This is the first instance in which an adult of this species has been recorded from India. Sewell (1919) has recorded the occurrence of the cercaria of this fluke from *Indoplanorbis exustus* and *Limnœa amygdalum* in Calcutta. The adult worms were found to differ from the typical forms in the dimensions of the body and the tuberculate nature of the cuticle. The first feature has been correlated with the smaller size of the body of Sewell's cercaria of *S. japonicum*. The tuberculate nature of the cuticle of *S. japonicum* has corroborated the writer's own previous observations in this respect in the cases of *Ornithobilharzia turkestanicum* and *S. spindalis*, this feature having no specific significance. The writer strongly deprecates the tendency to create new varieties within the limits of the same species, the best procedure being, in all such cases, to include in the specific description the several variations occurring. This will mitigate to a large extent the worries of a systematist in such a highly complicated and chaotic group as the parasitic worms.

Although up to the present moment the occurrence of this parasite in man has not been known in this country, it is likely that future investigation will reveal the presence of these worms in that host like many other porcine parasites that are common to human beings.

28. Helminth parasites of the Indian elephant from the Andamans.

G. D. Bhalerao, Muktesar.

An interesting collection of worms was received from the Andamans collected by Mr. Sen Gupta from the large intestine, larynx, and an oedematous swelling below the neck of an elephant. The collection contained five species of worms which were identified as *Pfenderius papillatus*, *Tagumœa heterocœca*, *Syngamus indicus*, *Equinurbia sipunculiformis*, and *Murshidia falcifer*. Although none of these worms are new to science, *Tagumœa heterocœca* and *Syngamus indicus* have not hitherto been recorded from India. The description of these two species hitherto available being very incomplete, has been thoroughly revised, and additional data are provided in regard to the other three.

29. A case of Clonorchis infection in Bihar.

K. N. Bagchi, Patna.

The incidence of flukes which affect man is very uncommon in India. Chandler in his survey of helminthic infections in India (*Ind. Jour. Med. Research*. Vol. 15, 730) states that *Fasciolopsis buski* infections are found as sporadic cases in most parts of India including Bihar and Orissa but no cases of Clonorchis infections were found in any part of India or Burma. A single case of Clonorchis infection was reported by Knowles but Chandler thinks that it was probably a case of Ophisthorchis which, according to his report, is very common in cats and dogs in Eastern India.

The case under reference is a Muhammadan male, aged 23, living in Patna. He consulted his doctors for treatment of enlarged liver and spleen, anæmia and occasional rise of temperature. Duration of his illness is about 9 years. Growth and development markedly arrested—looking like a boy of 13. Blood report—W.B.C.=10800, R.B.C.=3·77 million, Hb=45%. Serum tests for L.D. infection—negative. No m.p. The examination of his fæces showed only a few golden yellow, operculated ova measuring 27·6 μ × 15·9 μ (average dimensions of three ova which were found in four consecutive samples of his fæces). No ova of ankylostoma nor of any other worms could be detected in any of these examinations.

The shape, size, and colour of these ova resemble those of the ova of Ophisthorchis and Heterophyes so closely that they are indistinguishable and actual identification can only be made by examining the worms themselves. But the clinical picture of the case is suggestive of Clonorchis infection which is very common in China, Japan, and other far eastern countries. No response to treatment whatsoever was obtained.

30. Studies in mosquitoes and mosquito-transmitted diseases in Calcutta.

B. C. Basu, Calcutta.

The density of breeding of *Anopheles stephensi* Liston has been kept under close observation for a period of four years (July, 1928 to June, 1932), month by month in an area around the School of Tropical Medicine, Calcutta, consisting of ward 8 and part of wards 7 and 9, together with observations on the limits of distribution of this species, which has been found breeding everywhere throughout Calcutta and Howrah and even as far afield as Konnogar, 9 miles north of Howrah station. Some 21 different types of breeding places have been observed. During the same four years the density of breeding of *Aedes aegypti* L. in the same area has been studied and during the last two years (of the above four years) that of *Culex fatigans* Wiedemann. The detailed rainfall, temperature, and humidity figures are at hand together with figures showing the hourly variations of relative humidity during the day at different seasons of the year. Figures for the incidence of fresh cases of malaria and dengue admitted during these four years have been collected from the Civil and Military Hospitals of Calcutta City, whilst those for filariasis from School of Tropical Medicine only. The whole mass of data is under investigation but already the following interesting information has been gleaned :—

(i) Nearly half the total catch of *A. Stephensi* occurs in July and August, the peak months; the peak of fresh malaria infections is in October and November whilst the peak for malignant tertian incidence is October to December, when the *A. Stephensi* curve is falling very rapidly indeed. This want of correlation may partly explain why malaria does not become epidemic in Calcutta City.

(ii) The peak of *Aedes* density is in July and August and fits in extremely closely with that for admissions for dengue. This explains why this disease so often assumes severe epidemic form in Calcutta.

(iii) The incubation period for filariasis is difficult to determine and the curve for new admissions is more or less uniform throughout the year. On the other hand, the density of Culex breeding reaches its peak in November, a period when conditions are very unfavourable for the development of *F. bancrofti* in *C. fatigans.*

31. Contribution to the study of the schizogony of the so-called Hæmocystidium with reference to the validity of the sp. *H. Kopki* Mihi 1916.

Col. I. FROILANO DE MELLO, Nova Goa.

Conclusions.—The schizogony of *Hœmocystidium (Hœmoproteus) Kopki* occurs in the pulmonary endothelium of the infected lizard *Hemidactylus brookei* according to a process very similar to the schizogony of bird *Hœmoproteus.*

This character, joined to many others showing already the identity of both genera *Hœmocystidium* and *Hœmoproteus*, establishes definitely this identity and, so, the genus *Hœmocystidium* of Castellani and Willey becomes a synonym of *Hœmoproteus* Kruse.

The morphological characters of *Hœmoproteus (Hœmocystidium) Kopki* are entirely different from those of *Hœmoproteus (Hœmocystidium) Simondi* and both these species are autonomous and not identical as stated by Wenyon.

32. Lichen tropicus in horses.

S. C. A. DATTA, Muktesar.

'Lichen tropicus' is the name recently given to a chronic equine condition, which has been known since about 1883 to occur in various parts of India. It is remarkable that up till now the cause has not been ascertained nor has any satisfactory method of treatment been evolved. The disease is characterized by its seasonal occurrence, being prevalent during the hot weather and disappearing with the advent of the winter. The disease is generally restricted to the more hairy parts and hence the term 'Mane' and 'Tail' disease, and although the human condition 'lichen tropicus' has no resemblance to this condition. The term 'lichen' describes truly the clinical picture.

As a result of histopathological studies upon specimens of skin from clinical cases, the author reviews the existing hypotheses regarding the condition and records certain interesting and constant feature such as the presence of eosinophiles and microfilaria.

33. Treatment of follicular mange in dogs.

S. K. SEN, Muktesar.

The paper reviews the present position concerning the prospects of obtaining cures in the treatment of follicular mange of dogs (caused by *Demodex folliculorum*). A perusal of the available literature shows that the treatment of this condition has been attempted along four well-defined routes, namely, (1) Dressings; (2) Fumigation; (3) Drug Injections; and (4) Radiant Therapy. Of the remedies comprised under the first category, Rotenone deserves special mention in view of the surprisingly good results recently obtained by Crane (1933) in United States of America from the use of this drug, whilst of the more easily procurable remedies, mention may be made of the following formula recommended by Alston (1933): Lard, 1 part; Sulphur, 1 part; and Phenol added to make about 5 per cent. of the mass. Treatment by fumigation and drug injections does not appear as yet to have been given any extended trials, but ultra-violet radiation has been found beneficial, at any rate, in cases of circumscribed infection.

34. Studies on metallic contamination of Indian foods. I. Effect of cooking or storage of food in metallic vessels.

N. C. DATTA, Bangalore.

The increasing popularity of the use of metallic vessels, particularly in South India, for cooking and storing articles of food has now led to serious problem, which requires careful investigation. Some of the food preparations like *Rasam* or pickles are rich in salts and highly acid (as compared with similar preparations in most parts of the world) and are being cooked or stored in aluminium, lead, brass (tinned or otherwise) or bronze vessels, so that considerable quantities of the corresponding metals pass into solution and are thus consumed. The effect of such metallic contamination may not be immediately felt, or perhaps, even in a single generation, but their ultimate effect will have to be carefully considered in the interest of future generations. The present investigation was undertaken with the object of throwing some light on the above and related problems.

The following observations may be of interest :—

(i) Representative specimens of *Rasam* (clear soup) from a hotel were found to contain 5·2 parts per million of tin, 1·0 part of lead, 4·6 parts of aluminium, 12·0 parts of iron, and 3·6 parts of copper.

(ii) Young rats maintained on diet of rice and *Rasam* prepared in newly tinned brass vessel with supplement of Vitamins A and B declined and died in the course of a month. Similar animals fed with same diet prepared in aluminium vessel made slow growth.

(iii) Lactic fermented and kept in aluminium vessel for 18 hours had an aluminium content of 11·12 parts per million while that prepared in glass vessel contained only 0·45 parts per million. Rats maintained on curd from 20 c.c. of milk prepared in aluminium vessel, had normal growth, kept up healthy appearance and grew equally well as those getting same quantity of curd from glass vessel.

35. Investigation on the preparation of some colloidal solutions for medicinal use.

A. S. BHATTACHARYYA, Calcutta.

The theories and requirements of colloidal particles for application to medicinal purpose have been discussed. Some experiments have been carried out to obtain an idea of the nature of composition of some of the colloidal preparations sold in the market. Difficulties met with in preparing the medicinal colloids with some standard methods, as has been actually observed, have been stated : A method of preparing a protected Manganese oxide sol has been given which contained manganese to the extent of 0·1 gm. atom per litre in the presence of 0·02 mol. of Sodium or Potassium ion. Conclusion.

36. Iodine treatment in gastro-enterological therapeutics.

D. TALEC, Pondicherry.

The use of iodine in the treatment of gastro-intestinal diseases has been partly stopped, owing to its irritating effect on gastric mucosa and to iodism.

A new French preparation, Amiphène (Dioxyphen-Iodosulfonate of Potassium, $\mathrm{C6H^4O^5SKI}$, containing 33 % of iodine), did not give us any of the above-mentioned troubles.

We have used it in the diarrhœas of fermentation, putrefaction, in the dysenterylike diarrhœas and in six cases of amœbic dysentery confirmed by bacteriological test, excluding all other treatment. Results were very favourable and in the amœbic dysentery we had success in five out of six cases.

DAILY DOSES :—

Ordinary diarrhœas	0·75 to 1 gramme.
Dysenterylike diarrhœas ..	1·50 to 2 grammes.
Amœbic dysentery	2 grs. to 4 grs.

No sign of intolerance or iodism. However there is advantage in amœbic dysentery to combine with this medication per os, the use of amiphène in enema. 2·5 of amiphène are soluble in one hundred parts of cold water.

This solution can be sterilized by boiling. It is better to add to the cooled solution 2·50 grammes of sodium bicarbonate to increase its tolerance by the mucosa.

Alkalinity or acidity of intestinal tracts is important to know; the liberation of iodine from amiphène being obtained in alkaline media only.

37. Use of water contaminated with sewage for dilution of potable spirit.

A. G. GOKHALE, Nasik.

Experiments were made to find the effect of dilute Ethyl Alcohol (spirit) on *B. Coli* by diluting spirit with water artificially mixed with sewage. 23% and 34·3% alcohol kills the *B. Coli* organisms. Waters slightly contaminated with sewage are harmless for diluting potable spirit of the above strengths.

38. A preliminary study of the maternal death-rate and the proportion of still-births in Bengal for the period 1848–1901.

P. C. MAHALANOBIS *and* A. C. NAG, Calcutta.

Sir Kedarnath Das had collected data relating to maternity cases in Calcutta Hospitals covering the period 1848–1901. The variations of the maternal death-rate and the proportion of still-births (for male and female children separately) have been studied in the present paper in detail. There was a steady fall which could be represented by linear trends in all three cases, but the rates of fall were all different. Variations from month to month were also statistically significant although no simple relation could be traced. The question of correlation between the different rates has also been discussed in detail.

39. Vitamins A and D in Indian fish liver oils.

B. C. GUHA *and* A. R. GHOSH.

The potency of the liver oils of certain common Bengal fishes, like the *hilsha, mrigal, vetki, rohit, katla, dhain, kalibaus, ar, chital,* etc., with reference to vitamin A has been investigated both tintometrically by the Carr-Price technique and biologically. Many of these are considerably more potent than cod liver oil. The tintometric and biological methods, however, do not always give concordant results.

Some of the above liver oils have also been studied with regard to the content of vitamin D by estimating the minimum doses, that would prevent experimental rickets in young rats.

40. Studies on infantile biliary cirrhosis. Part I. Introduction and a review of the literature.

T. S. Tirumurti *and* M. V. Radhakrishnarao,
Vizagapatam.

This paper is an introduction to the investigation on 'Infantile Biliary Cirrhosis' in Vizagapatam. by the junior author. The available literature on the subject is briefly reviewed with the idea of presenting the views expressed by different observers about the ætiology of the disease.

41. The incidence of portal cirrhosis of the liver in Vizagapatam, based on a critical study of autopsy records and observations.

T. S. Tirumurti *and* M. V. Radhakrishnarao,
Vizagapatam.

A critical study of the recorded observations on autopsies performed in the King George's Medical College and Hospital, Vizagapatam, definitely shows that the incidence of portal cirrhosis of the liver is rather high (56·0 per cent. of all cases of cirrhosis of the liver) in this part of India. Primary splenic was the cause of portal cirrhosis in a few cases (6 per cent.), while in the rest (50 per cent.) the causation is far from clear. The pathological appearances of the liver in these cases are described and it is shown that in a few cases 'nodular hyperplasia' was seen. Alcohol does not play any part in the ætiology of the disease which is probably of the nature of 'toxic cirrhosis' (Mallory) due to repeated toxic or tox-infectious process, the nature of which remains to be determined.

42. A simple method for the approximate estimation of the ovulation producing substance from the urine of pregnant women (by the Rabbit Ovulation Test).

S. B. Anklesaria *and* M. Mehta, Bombay.

A simple method of injecting increasingly small amounts of the first morning sample of urine into an isolated mature female rabbit is suggested for the estimation of the amount of ovulation producing substance in the urine of pregnant women. About 100 tests have been performed with 12 cases of vesicular moles and chorionepithelioma and 107 experiments with 18 cases of normal pregnancy at various periods of gestation.

During the presence of a vesicular mole or chorionepithelioma in the body the urine gives a positive reaction with $\frac{1}{32}$ to $\frac{1}{125}$ c.c. This gradually drops after its expulsion or removal so that at about 2 months the reaction is negative even with 24 c.c. In one case the reaction, however, remained positive with 2 c.c. up to $14\frac{1}{2}$ weeks after removal of a vesicular mole.

During normal pregnancy the urine gives, between $1\frac{1}{2}$ and $2\frac{1}{2}$ months, a positive reaction with $\frac{1}{16}$ to $\frac{1}{64}$ c.c. However, at about $2\frac{1}{2}$ months this drops to a positive reaction with $\frac{1}{4}$ c.c. and a negative reaction with $\frac{1}{8}$ c.c.

This method may not be very accurate. The idea was to evolve a simple and practical technic and not a very elaborate and accurate one. As the results indicate it suffices for clinical purposes for if a pregnant patient, $2\frac{1}{2}$ *months or more,* gives a positive reaction with $\frac{1}{32}$ c.c. or more the diagnosis of a vesicular mole is supported. Again, after the passage of a vesicular mole if the hormone excretion does not drop gradually it would help us to diagnose a chorionepithelioma much earlier. With the ordinary technic it is not possible to be sure on this point before 2 months as the urine may give a positive test up to 2 months after passage of the mole without the case being necessarily one of a chorionepithelioma.

Section of Anthropology.

President :—RAI BAHADUR RAMAPRASAD CHANDA, B.A., F.A.S.B.

Presidential Address.

ŚRAMAṆISM.

GENTLEMEN,

The honourable and responsible position which you have very kindly invited me to occupy to-day has hitherto been rightly reserved for scholars engaged in studying the primitive tribes and physical features of man in India. Though anthropology or the history of man as regulated by the laws of evolution and heredity includes the prehistory as well as the history of man, and among men, the history of the primitive tribes as well as the progressive nations, by a healthy division of labour which is as much necessary in this field of science as in other fields of human activities, the term has been appropriated to the prehistory, the physical history, and the history of the primitive cultures of man. My own investigations have been confined to the history of the civilization of the Hindus from literary sources and lithic monuments. So I hope I shall not be accused of feigning modesty if I plead at the outset my incompetence for guiding your deliberations and crave your indulgence for my shortcomings.

Thirty years ago the late Sir Herbert Risley's Census of India Report gave a strong impetus to anthropological studies in India. Dr. J. H. Hutton's recently published Report of the last Census not only gives the essence of the results of the researches of the last thirty years, but the author's own contributions mark an important step in advance. In the sections on Linguistic pre-history and Race he has condensed the contents of volumes with illuminating suggestions. Dr. Hutton's essay on Hinduism in relation to primitive religion opens up an important line of research, which, I hope, he himself will carry forward, and bring to light the intermediate stages between the primitive and the non-primitive by taking leave of the head-hunters and fixing himself up near the shrine of Kāmākhyā in Kamrup.

1. *Brāhmans and Śramaṇas in the Fourth Century B.C.*

No problem of Indian ethnography has attracted greater attention of the anthropologists than the origin of caste. In Brāhmanic texts with caste is associated another institution called *āśrama*, order, and Brāhmanic Hinduism bears the name

Varṇāśramadharma, the *dharma* of castes and orders. The term *dharma* not only denotes religion, but also law, both written and customary, and hereafter I shall use this word in original without attempting to give its English equivalent. Like four primary castes, there are four *āśramas* or orders, the order of the Vedic students (*brahmacārin*), the order of the householders (*gṛihastha*), the order of the hermits in the wood (*vānaprastha*), and the order of the religious mendicants (*bhikṣu*, *yati*, *sanyāsin* or *paribrājaka*). The orders of students and householders are universal. The orders of the forest-dwellers and religious mendicants probably originated in India. In this address I shall endeavour to trace the origin of these monastic orders.

In the dialogues of the Buddha religious teachers are divided into two classes, the brāhmans and śramaṇas, the name brāhman being reserved for brāhman householders who were priests and preceptors, and the term *śramaṇa* was applied to both forest-dwellers and mendicants. The same classification is made by the Greek ambassador Megasthenes who lived at the court of the Maurya emperor Chandragupta at Pāṭaliputra about 300 B.C. His account quoted by Strabo (15. 59) is reproduced below :—

'Megasthenes makes another division in his discussion of the philosophers, asserting that there are two kinds of them, one called Brachmanes (brāhmans) and the other Garmanes (śramaṇas) ; that the Brachmanes, however, enjoy fairer repute, for they are more in agreement in their dogmas ; and that from conception, while in the womb, the children are under the care of learned men, who are reputed to go to the mother and the unborn child, and, ostensively, to enchant them a happy birth, but in truth to give prudent suggestions and advice ; ......and after the birth of children different persons, one after another, succeed to the care of them, the children always getting more accomplished teachers as they advance in years ; and that the philosophers tarry in a grove in front of the city in an enclosure merely commensurate with their needs, leading a frugal life, lying on straw mattresses and skins, abstaining from animal food and delights of love, and hearkening only to earnest words, and communicating also with any one who wishes to hear them ; ....and that, after having lived in this way for thirty-seven years, they retire, each man to his own possessions, where they live more freely and under less restraint, wearing linen garments, ornaments of gold in moderation in their ears and on their hands,........and that they marry as many wives as possible, in order to have numerous children.........but that the Brachmanes do not share their philosophy with their wedded wives........and that they converse more about death than anything else, for they believe that the life here is, as it were, that of a babe still in the womb, and that death, to those who have devoted themselves to philosophy, is birth into the true life, that is, happy life; and that they therefore discipline themselves most of all to be ready for death.' [1]

Here we have a fairly accurate account and a Greek's interpretation of the rites and usages of a brahman householder at the end of the fourth century B.C. The account of the ceremonies performed by learned men when the child is in the womb no doubt gives a Greek's view of the ceremonies during pregnancy, *puṁsavana*, the rite to insure a male child, and *sīmantonnayana*, the parting of hair. All rites that are performed for a male child till his initiation and entrance into the order of the Vedic students Megasthenes regards as earlier stages of education. His account of the life of a student (Brāhmacārin) is fairly accurate. Regarding the duration of studentship (37 years) Megasthenes is wrong by one year only, for Manu provides (III. 1), 'The vow of studying the three Vedas under a teacher must be kept for thirty-six years, or for half that time, or for a quarter, or until the student has perfectly learnt them'. Arrian, following Megasthenes, says of the sophists (philosophers):—

'Nor indeed is any duty absolutely binding on them except to perform the sacrifices offered to the gods on behalf of the state. If any one, again, has a private sacrifice to offer, one of these sophists shows him the proper mode, as if he could not otherwise make an acceptable offering to the gods'.[2]

The sacrifices referred to here are Vedic sacrifices which a non-brāhman could perform only through a brāhman priest. So the sophists referred to by Arrian are brāhman householders. These extracts from Megasthenes preserved by Arrian and Strabo show that about 300 B.C. brāhman students and brāhman householders on the whole lived in accordance with the rules laid down for their orders in the Dharmaśāstras or brāhmanic codes. To the rules laid down in the Dharmaśāstras or Smṛitis for the guidance of the Vedic students and the order of householders of all castes I shall restrict the term Brāhmanism.

Strabo then quotes this account of the *śramaṇas* from Megasthenes (15. 60):—

'As for the Garmanes (*śramaṇas*), he says that the most honourable of them are named Hylobii and that they live in forests, subsisting on leaves and wild fruits, clothed with the bark of trees, and abstaining from wine and the delights of love: and that they communicate with the kings, who through messengers inquire about the causes of things and through the

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[1] Extracts from *The Geography of Strabo* are from H. L. James' translation (The Loeb Classical Library).

[2] MacCrindle, *Ancient India as described by Megasthenes and Arrian*, Calcutta, 1877, p. 209.

Hylobii worship and supplicate the Divinity; and that, after the Hylobii, the physicians are second in honour, and that they are, as it were, humanitarian philosophers, men who are of frugal habits but do not live out of doors, and subsist upon rice and barley-groats, which are given to them by everyone of whom they beg or who offers them hospitality; and that through sorcery they can cause people to have numerous offspring, and to have male or female children;..........and that both this class and the other practise such endurance, both in toils and in perseverance, that they stay in one posture all day long without moving;...........and that women, as well as men, study philosophy with some of them, and that the women likewise abstain from the delights of love.'

The Hylobii were the *Vānaprasthas*, hermits in the wood, who are required by the Dharmaśāstras to live in the forest, subsist on roots and fruits, and wear bark of trees. The other class of śramaṇas called physicians by Megasthenes who lived on alms are no doubt the different orders of the *bhikṣus*, *yatis*, or *sanyāsis*. Megasthenes rightly says that both these classes of śramaṇas practised self-mortification (endurance) and *dhyāna-yoga* (meditation) seated or standing in a fixed posture. The brāhmans did not permit women to study the Vedas, but the Buddhists admitted women to the Saṁgha (order) as nuns and of course allowed them to study the Buddhist scripture which is called philosophy by Megasthenes. The practices of all classes of śramaṇas, whether living in the forest or living on alms, and their adoration by laymen I shall designate by the name Śramaṇism.

Megasthenes lived at Pāṭaliputra (Patna) and must have seen much of the brāhmans and the śramaṇas of Eastern India. Over a quarter of a century before (326 B.C.), Alexander the Great invaded Gandhara and the Punjab and made inquiries about the Indian sophists at Taxila. From the writings of his companions, Aristobculus, Onesicritus, and Nearchus quoted by Strabo (15. 61–68) it is evident that there were also the same two classes of religious preceptors, the brāhmans and the śramaṇas, in North-Western India. One of the śramaṇas, Calanus (Kalyāna), a naked ascetic of Taxila, accompanied Alexander to Pasargadae in Persia, fell ill, and burnt himself to death on a pyre. Strabo quotes the following comments of Megasthenes on this event :—

'But Megasthenes says that suicide is not a dogma among the philosophers, and that those who commit suicide are adjudged guilty of the impetuosity of youth; that some who are by nature hardy rush to meet a blow or over precipices: whereas others who shrink from suffering, plunge into deep waters; and others, who are much suffering, hang themselves; and others who have fiery temperament, fling themselves into fire; and that such was Calanus, a man who was without self-control and a slave to the table of Alexander' (15. 68).

The spirit of renunciation and self-sacrifice is the underlying principle of Śramanism. After the renunciation of home and comforts of life and the practice of self-mortification, the next stage in the course of asceticism is suicide or renunciation of life. It is stated in the *Kalpasūtra* that the Jain Tirthankaras or Jinas Pārśva and Ariṣṭanemi died after fasting a month without drinking water. But Megasthenes' statement 'that suicide is not a dogma among the philosophers' is supported by the early Buddhist and Brahmanic records. In the Pali *Mājjhima-Nikāya*, No. 144, it is said that a follower of the Buddha, a śramaṇa named Channa, fell seriously ill. He found his pain unbearable and said to another monk Sāriputta, 'I shall use a knife on myself and that without blame attaching to me'. Later on Channa committed suicide by using a knife on himself. Sariputta brought the news to the Buddha and asked him, 'What future awaited Channa'. The Buddha replied :—

'That term (blameworthy) I apply to a man who divests himself of this body because he wants another. This was not the case with Channa, who was blameless in using the knife upon himself.'[1]

The meaning of this statement evidently is, that as Channa is not liable to rebirth (i.e. he has gained Nirvāṇa), no blame or sin attaches to him for suicide. But suicide is against the spirit of the teachings attributed to Gautama Buddha who prescribed for the śramaṇas a middle course between worldly pleasures and useless self-torture. Buddhist attitude towards suicide is best expressed in a dialogue of the Dīgha-Nikāya (No. 23). Pāyāsi, a chieftain of Kosala (Oudh), says, addressing Kumāra Kassapa, a distinguished śramaṇa of the Buddha's order :—

'I see śramaṇas and brāhmans moral and of virtuous dispositions, fond of life, averse from dying, fond of happiness, shrinking from sorrow. Then I think, Master Kassapa :—" If these good śramaṇas and brāhmans were to know this—when once we are dead we shall be better off—then these good men would have taken poison, or stab themselves, by hanging, or throw themselves from precipices ".'

Kumāra Kassapa replied :—

'Moral and virtuous śramaṇas and brāhmans do not force maturity on that which is unripe ; they being wise, wait for that maturity. The virtuous have need of their life. In proportion to the length of time such men abide here, is the abundant merit that they produce and accomplish for the welfare of the many, for the happiness of many, out of compassion for the world, for the advantage, the welfare, the happiness of gods, and men.'[1]

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[1] Lord Chalmers, *Further Dialogues of the Buddha*, Vol. II, London, 1927, pp. 305–307.

The case against suicide could not be more clearly stated. In the ancient Brahmanic texts suicide is strictly forbidden. Medhātithi in his commentary on Manu (5. 27) quotes this Śruti or passage from a Brāhmaṇa part of one of the Vedas :—

'One must save one's life by all means ; therefore one should not put an end to oneself before the end of the normal term of life for gaining heaven. He who does so (i.e. commits suicide) is unworthy of reaching (higher) worlds.'[2]

Medhātithi also quotes this stanza (3) from the Iśā-Upaniṣad as forbidding suicide :—

'Men who commit self-murder (*ātmahan*) go after death to the devilish worlds covered by deep darkness.'[3]

Śaṅkara, the famous commentator of the old Upaniṣads and the Vedāntasūtras, takes *ātmahan*, self-murderer, in a figurative sense meaning one who is ignorant of the true nature of *ātman* (soul). In the preceding stanza (2) of the Iśā-Upaniṣad it is stated, 'Performing works here (i.e. in this life) let a man wish to live a hundred years; thus works will not cling to thee, man ; there is no other way'.[4] Therefore the literal explanation of *ātmahan* adopted by Medhātithi is the more appropriate. Mādhava in his commentary on the Parāśara-smriti (4. 30) follows Medhātithi. Calanus was one of the naked śramaṇas who practised self-mortification by exposing themselves to the sun either sitting, standing, or lying in fixed posture (Strabo 15. 63). In a dialogue of the Mājjhima Nikāya (No. 14) the Buddha is made to say of the Nirgrantha or Jain śramaṇas :—

'Once on a time, when I was staying at Rājagaha on the Vultures' Peak, there were a number of Nigaṇṭhas (Nirgranthas) at Blackrock on the slopes of Mt. Isigili,—upright men who would never sit down, and undergoing paroxysms of acute pain and agony...... Their answer was that Nātaputta (Jñātṛiputra) the Nigaṇṭha.........had taught them as follows :—Nigaṇṭhas, you have done evil in the past ;—extirpate it by these severe austerities.'[5]

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[1] T. W. and C. A. F. Rhys Davids, *Dialogues of the Buddha*, London, 1910, pp. 357-358.

[2] सर्वत एवात्मानं गोपायेत्तस्मादुह न पुरायुषः स्वःकामी प्रेयादलोक्यं ह्येतद्भवतीत्यादि ।

[3] असुर्या नाम ते लोका अन्धेन तमसावृताः ।
तां स्ते प्रेत्याभिगच्छन्ति ये केचात्महनो जनाः ॥

[4] Thibaut's translation.

[5] Lord Chalmers, *Further Dialogues of the Buddha*, Vol. I, London, 1926, p. 67.

Calanus was either a Jain śramaṇa, or belonged to some other order which held similar views about the efficacy of self-mortification and suicide.[1]

2. *Early History of Śramaṇism.*

This examination of the statements of Onesicritus and Megasthenes regarding the usages of the brāhmans and the śramaṇas in the last quarter of the fourth century B.C. shows that they are substantially correct. Therefore the accounts of these Greek writers form a chronological landmark in the history of both the brāhmans and the śramaṇas from which we may reconstruct their history backward and forward on the basis of Indian literary sources with some degree of certainty. Megasthenes' account of the śramaṇas shows that both the orders of the Vānaprasthas (Hylobii), hermits in the wood, and the *bhikṣus*, religious mendicants, were well established by that time. The Hylobii were recruited from among the brāhmans or the Brāhmanists and they are required by the *Dharmasūtras* to recite the Veda daily (Āpastamba, 2. 9. 21. 21), kindle the fire according to the rule of the Śrāmaṇaka sūtra, and offer oblations in the morning and evening (Gautama, 3. 27). But the earliest extant Dharmasūtras,—those of Āpastamba, Vasiṣṭha, Baudhāyana, and Gautama refer back to a time when the legality of entering the order of the Hylobii and the *bhikṣus* was still a matter of dispute. So these texts may be assigned to an age considerably earlier than that of Megasthenes. A similar conclusion was arrived at by Bühler, the translator of these texts, on other grounds. He writes about the age of Āpastamba :—

'On linguistic grounds it seems to me Apastamba can not be placed later than the third century B.C., and if his statement regarding Śvetaketu is taken into account, the lower limit of the composition of his sūtras must be put further back by 150–200 years.'[1]

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[1] Strabo (15. 73) writes on the authority of Nicolaris Damascenus that an embassy sent by an Indian king to Augustus Cæsar (B.C. 44—A.D. 14) was accompanied by a man who burned himself up at Athens; and that whereas some commit suicide when they suffer adversity, seeking release from the ills at hand, others do so when their lot is happy, as was the case with that man ; for, he adds, although that man had fared as he wished up to that time, he thought it necessary then to depart this life, lest something untoward might happen to him if he tarried here ; and that therefore he leaped upon the pyre with a laugh, his naked body anointed, wearing only a loin-cloth ; and that the following words were inscribed on his tomb : ' Here lies Zarmanochegas, an Indian from Bargosa [i.e. Bhrigukaccha or Broach], who immortalized himself in accordance with the ancestral customs of the Indians '.

The name *Zarmanochegas* may be restored as *śramaṇa Tyāga*, and he ' immortalized himself ' means that he gained immortality after death by committing suicide.

In round number this calculation will give about 400 B.C. as the date of Āpastamba. Bühler places the works of Vasiṣṭha, Baudhāyana, and Gautama earlier still. I shall take these Dharmasūtras to represent the views of the Smārtas or students of the Dharmaśāstras or Smṛitis of the fifth century B.C. Gautama, after giving the rules for the conduct of the Vānaprasthas and the bhikṣus, concludes (3. 36):—

'But the venerable teacher (*ācārya*) prescribes one order only, because the order of householders is explicitly prescribed in the Vedas.'[2]

Baudhāyana also attributes a similar opinion to his teacher (2. 6. 11. 27):—

'But the venerable teacher (declares) that there is one order only, because the others do not beget offspring.'

The one order referred to by Baudhāyana is of course the order of the householders. He then proceeds:—

'With reference to this matter they quote also (the following passage): "There was forsooth an Āsura, Kapila by name, the son of Prahlāda. Striving with the gods, he made these divisions. A wise man should not take heed of them".'

These divisions are the division of men into four orders. This extract enjoins that as the division into ascetic orders is the work of an Āsura, the enemy of the Devas, wise men should not recognize any but the order of the householders. In the conclusion of the section (2. 6. 11) Baudhāyana gives other extracts to support his opposition to the orders of the śramaṇas (*Vānaprasthas* and *Sanyāsīs*):—

'There are innumerable (passages in the Veda), which refer to the debts (to be paid by a brāhman) such as, "May I obtain, O Agni, immortality through offspring": "A brāhman on being born (owes) a son to his ancestors", etc.

'"Those dwell with us, who fulfil the following (duties), the study of the three Vedas, the studentship, the procreation of offspring, faith, austerity (*tapas*), sacrificing, and giving gifts; he who praises other (duties) becomes dust and perish".'

This last passage is also quoted by Āpastamba (6, 2. 9, 24. 7-8) and is attributed to Prajāpati. Vasiṣṭha in his Dharmasūtra declares his preference for the order of householders and asserts that a householder who performs his proper duties is not liable to rebirth. He writes (8, 14 and 17):—

'A householder alone performs sacrifices, a householder alone performs austerities. and (therefore) the order of householders is the most distinguished among the four.

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[1] *Sacred Books of the East*, Vol. II, Oxford, 1897, p. xlvi.

[2] This and other extracts from the Dharmasūtras are quoted from Bühler's translation, *Sacred Books of the East*, Vols. II and XIV.

* * * *

'A brāhman who always keeps water (in his house). who always wears the sacred thread, who daily recites the Veda. who avoids the food of outcasts, who approaches (his wife) in the proper season. and offers sacrifices in accordance with the rules (of the Veda. after death) never falls from Brahma's heaven.'

Evidences supporting the orders of the hermits and the bhikṣus are fully discussed by Āpastamba. He quotes the following stanzas from an unnamed Purāṇa (6, 9. 23. 3–6):—

'Now they quote (the following two verses) from a Purāṇa:

'Those eighty-eight thousand Ṛiṣis who desired offspring passed to the south by Aryaman's road and obtained *śmaśānas* (died).

'Those eighty-eight thousand Ṛiṣis who desired no offspring passed by Aryaman's road to the north and obtained immortality.

'Thus are praised those who keep the vow of chastity (*ūrdhаretas*).'

Śaṅkara in his commentary on the *Brihad-Āraṇyaka Upaniṣad* (6. 2. 15) quotes a variant of the second stanza as an extract from a *smṛiti*.[1] Another argument in favour of the hermits and the ascetics referred to by Āpastamba is their power of working miracles (accomplishing wishes merely by conceiving them). He then proceeds:—

'Therefore on account of (passages) of the revealed texts. and on account of the visible results, some declare these orders (of men keeping the vow of chastity to be) the most excellent.'

To these arguments Āpastamba replies:—

'But it is the firm opinion of those who are well-versed in the threefold sacred learning (*traividyavṛiddhānām*), that the Vedas are the highest authority. They consider that the (rites) which are ordered to be performed with rice, barley, animals, clarified butter, milk, potsherd (in conjunction with), wife (and accompanied) by loud or muttered (*mantras*). must be performed, and that (hence) a rule of conduct which is opposed to these rites, is of no authority. But by the term *śmasāna* (in the text above given) it is intended to ordain the last rites for those who have performed many sacrifices (and not to mean that dead householders become demons and haunt burial-grounds). The revealed texts declare that after (death follows) a reward without end, which is designated by the term "heavenly bliss".'

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[1] अष्टाशीतिसहस्राणामृषीणामूर्ध्वरेतसाम् ।
उत्तरेणार्यम्णः पन्थास्तेऽमृतत्वं हि भेजिरे ॥

These extracts from the earliest available Dharmasūtras make it clear that in the opinion of their authors :—

(1) One can gain reward without end, eternal heavenly bliss, escape from rebirth, and the world of Brahma from which there is no return, by performing the pious duties incumbent on a householder.

(2) The orders of the śramaṇas (Vānaprasthas and Bhikṣus) are not provided by the Vedas.

Each of the Vedas, or, rather, each recension of each of the Vedas, consists of two parts, Mantra and Brāhmaṇa. The hymns and the prose formulas contained in the Vedic Samhitās are known as Mantra, and the prose treatise attached to each version of a Veda Samhitā is called the Brāhmaṇa. The Āraṇyakas including the Upaniṣad are appended to the Brāhmaṇa. The *Brihad-Āraṇayaka-Upaniṣad* is appended to the *Śatapatha Brāhmaṇa* of the *White Yajurveda*, and the *Chāndogya Upaniṣad* to the Brāhmaṇa of the Kauthuma recension of the Sāmaveda. The text of the Brāhmaṇa including the Upaniṣad consist of two kinds of passages, *vidhi*, injunction including prohibition, and *arthavāda*, explanatory remarks. The authors of the Dharmaśāstras referred to above say that the Veda or Śruti, meaning the Brāhmaṇa texts including the Upaniṣads, contain no injunction for entering the orders of the śramaṇas. If this is so, and if it is also stated in the Brāhmaṇas and the Upaniṣads that one can escape rebirth and gain immortality after death by performing the sacred duties of a householder, Sramaṇism cannot be considered as an offshoot of Brāhmanism or a Vedic Aryan institution, but must have originated among people who originally lived outside the pale of Vedic Aryanism. In plain language, the authors of the Dharmasūtras represent Śramaṇism as a non-Aryan institution.

3. *Origin of Śramaṇism.*

The view of the ancient Smārtas or authors and followers of the Dharmaśāstras regarding the non-Vedic origin of Śramaṇism is opposed by Bādarāyaṇa in his Vedāntasūtras in which the teachings of the Upaniṣads are systematized and which is therefore known as the *Uttara-Mimāṁsā*, the systematization of the latter (Upaniṣad) part of the Veda, and is distinguished from the *Pūrva-Mimāṁsā* of Jaimini in which the teachings of the early (Brāhmaṇa) part of the Veda are systematized. Only a single collection of aphorisms (sūtras) of the Uttara-Mimāṁsā has come down to us. It is called the *Vedāntasūtra* or the *Brahmasūtra* or the *Sārīraka-Mīmāṁsā* and its authorship is attributed to Bādarāyaṇa (Vyāsa). In the Sūtras themselves Bādarāyaṇa is often named as an authority. So the authorship of the entire collection in its present form should rather be attributed to the school of Bādarāyaṇa than to Bādhrāyaṇa himself. The views of seven other authors including Jaimini are referred to in the Sūtras. So at one time there must have been in existence seven other *Vedāntasūtras* or seven other schools of Vedānta including one of Jaimini. Chapter III, Section 4 of the Vedāntasūtras opens with this aphorism :—

'The purpose of man (*mokṣa* or release from rebirths) is effected thence (i.e. through the knowledge of Brahman-Ātman), thus Bādarāyaṇa opines.' [1]

Both Śaṅkara and Rāmānuja quote passages from the Upaniṣads supporting this view in their commentaries. The implication of the Sūtra is that as Mokṣa can be obtained by the knowledge of Brahman-Ātman only, one need not perform the Vedic rites as a householder, but may renounce the *karma* or Vedic rites incumbent on a householder and pursue the knowledge of Brahman as a śramaṇa. In the next following aphorism is cited the opinion of Jaimini who says that the knowledge of Brahman occupies a subordinate place to *karma* (Vedic rites) on the path of *mokṣa* and that the passages of the Upaniṣads referred to by Bādarāyaṇa are not injunctions but mere *arthavādas*, explanations and laudatory statements. By subordinating knowledge of Brahman to the sacrificial rites Jaimini indicates that *mokṣa*, attainable by the knowledge of Brahman, can only be gained by householders who regularly perform Vedic sacrifices. In the five following Sūtras (3–7) Jaimini is made to refer to the passages of the Upaniṣads that support his view. These passages are quoted in full by the commentators. Some among these are reproduced in translation below :—

'Aśvapati Kaikeya had deep knowledge of the *Ātman* (self) ; but when three (? six) Ṛiṣis had come to him to receive instruction regarding the self, he told them "I am about to perform a sacrifice, Sir".' (*Chāndogya-U.* 5. 11. 5.)

'This did Brahmā tell to Prajāpati ; Prajāpati to Manu ; Manu to human beings (*prajā*).

'He who according to rule has learned the Veda from the family of a teacher, in time left over from doing work for the teacher ; he who, after having come back again, in a home (*kuṭumbe*) of his own continues Veda-study in a clean place and produces [sons and pupils] ; he who has concentrated all his senses upon the soul (Ātman) ; he who is harmless (*ahiṁsant*) toward all things elsewhere than at *tīrthas* (i.e. in accordance with the injunction of the scripture at animal sacrifices)—he, indeed, who lives thus throughout his length of life, reaches the Brahma-world and does not return hither again—yea, he does not return hither again.' (*Chāndogya-U.* 8. 15).[2]

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[1] English translation by Thibaut, *Sacred Books of the East*, Vol. XXXVIII.

[2] Hume's translation (*The thirteen Principal Upanishads*).

'The Agnihotra is sattra lasting up to old age and death; for through old age one is freed from it or through death' (*Śatapatha Brāhmaṇa*, 12. 4. 1. 1).

The Agnihotra sacrifice is performed by the householders only. So the question at issue between the two schools of the Vedānta—the school of Jaimini and the school of Bādarāyaṇa—is, whether one should renounce the duties of the householder—that is to say, the order of the householders (Gṛihasthas), for pursuing the knowledge of Brahman-Ātman. Jaimini's contention is that one should not leave the order of householders, for Aśvapati Kaikeya and others did not do so, and one can not do so in the face of the direct injunction of the Veda that Agnihotra should be performed up to old age. In the Sūtras embodying the rejoinder of Bādarāyaṇa passages of the Upaniṣads are also referred to. I shall quote some of these:—

'Knowing this Ṛiṣis descended from Kavaṣa said: For what purpose should we study the Veda? For what purpose should we sacrifice? Knowing this indeed the ancient ones did not offer the Agnihotra' (from an unknown Upaniṣad).

'When brāhmans know that Ātman (soul) and have risen above the desire for sons, wealth, and worlds, they wander about as mendicants' (*Bṛihadāraṇyaka-U.* 3. 5).

'Thus far goes immortality. Having said so—Yājñavalkya went away into the forest.' (*Bṛihadāraṇyaka-U.* 4. 5. 15).

'Knowing this *the people of old did not wish for offspring.* What shall we do with offspring, they said, we who have this Ātman and this world.' (*Bṛihadāraṇyaka-U.* 4. 4. 22).[1]

Jaimini's comment on these and other texts referred to by Bādarāyaṇa is embodied in the following Sūtra (3. 4. 18):—

'Jaimini [considers that scriptural passages mentioning those orders in which chastity (celibacy) is obligatory, contain] a reference (only to those orders); they are not injunctions; for (other scriptural passages) forbid (those orders).'

The sharp difference of opinion that existed among the different early schools of Vedānta over the question whether a man should renounce the order of householders and turn a śramaṇa for gaining knowledge of Brahman-Ātman is not without historical significance. Two of the texts quoted above show that in the period when the *Bṛihadāraṇyaka* and the *Chāndogya Upaniṣads* were composed learned brāhmans of the standing of Yājñavalkya and the descendants of Kavaṣa used to renounce the world and adopt the life of a śramaṇa to gain the knowledge of Brahman-Ātman. But in the earlier texts, in the *Śatapatha Brāhmaṇa* and other Brāhmaṇa texts no such instance is given. Renunciation of the world is not reconcilable with the religion of the Brāhmaṇa texts which could be practised only by householders. Who, then, could be *the people of old* who did not wish for offspring ? Who could be the *ancient ones* who did not offer the Agnihotra ? They could not have been brāhmans or Brāhmaṇists of the pre-Upaniṣadic age. The entire pre-Upaniṣadic Vedic literature is permeated by a strong love of life. Fear of re-death in heaven occasionally haunted the brāhmans of those days. But the remedy suggested is sacrificial rite and not renunciation. The only hypothesis that fits in with these facts is that Śramaṇism originated outside the pale of Brāhmanism or Vedic Aryanism, among the non-Aryans or the pre-Aryans. One of the designations of the *bhikṣu* (mendicant) order of the śramaṇas, as distinguished from the hermits in the wood, is *Yati.* In the Saṃhitās of the Black Yajurveda a legend is frequently narrated that Indra destroyed the *Yatis* by giving them away to Sālāvṛikas who ate them. This legend must have had its origin in the fact that the *Yatis* did not worship Indra, and worshippers of Indra tried to destroy them. The detailed versions of the legend tell us that the survivors among the *Yatis* were converted to the cult of Indra. We are told in the *Pañcaviṃśa Brāhmaṇa*, 13. 4. 17 :—

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[1] Thibaut's translation.

'Indra gave the Yatis over to the hyænas (*Sālāvṛikas*). Three of them were left over: Prithuraśmi, Bṛihadgiri, and Rāyovāja. These said : "Who will bear ('support') us (as his) son ? " "I ", answered Indra and he, having put them on (his back), roamed about tending them. Having tended them he said : " Boys, choose ye a boon ? " " Might for me ", said Prithuraśmi. To him he gave, by means of this pārthuraśma (sāman), might. . . . . " Priestly lustre for me ", said Bṛihadgiri. To him he gave, by means of this bārhadgira (sāman), priestly lustre. . . . . " Cattle to me ", said Rāyovāja. To him he gave, by this rāyovājīya (sāman), cattle.'[1]

This legend means that one of the surviving Yatis became Brāhman, another Kṣatriya, and the third became Vaiśya.

The slaughter of the Yatis was considered an impious act, as sinful as the slaying of Vṛitra. In the *Taittirīya Saṃhita* 3, 3, 7 it is said :—

'In that Indra slew Vṛitra, there is impurity, in that he destroyed the Yatis, there is impurity.'[2]

In the *Pañcaviṃśa Brāhmaṇa* (14. 11. 28 : 19. 4. 7) it is said :—

'Indra gave the Yatis over to the hyænas ; an inauspicious voice reproached him and he thought himself impure (*aśuddha*). He (thereupon) saw this śuddhāsuddhīya (sāman) and was purified by it.'

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[1] Caland's translation. For another version of the same legend (in the *Jaiminīya Brāhmaṇa*) see *J.A.O.S.*, Vol. XIX, pp. 124-125.

[2] Keith's translation, *H.O.S.*

In another passage (18. 1. 9) of the same Brāhmaṇa it is said that reproached by an inauspicious voice Indra resorted to Prajāpati who to him gave over the rite called Upahavya. Intervention of the inauspicious voice indicates that the Yatis were believed to have been favoured by superhuman agencies. In some of the hymns of the Ṛigveda the Yatis are referred to in a friendly spirit. In the Ṛigveda 8. 3. 9, Indra is said to have helped the Yatis and the Ṛiṣis Bhṛigu and Praskaṇva: in 8. 6. 18 it is said that the Yatis and the Bhṛigus praised Indra. The Yatis are deified in the Ṛigveda 10. 72. 7. In a stanza of the Sāmaveda (2. 304) that does not recur in the Ṛigveda the Yati is classed with Indra and Mitra as the slayer of Vṛitra.[1]

These references show clearly that the Yatis were a religious order respected in the early Vedic (Ṛigvedic) and cruelly persecuted in the later Vedic period. Like all other religious persecutions, the persecution of the Yatis should be attributed, not only to their heterodoxy, but to their efforts to propagate their own practices among the orthodox followers of the Vedic religion. Very probably the ancient Yatis, like the later ones, preached the abandonment of the Vedic rites, and invited the householders to give gifts to themselves.

If there were Yatis in the early Vedic age, the order may be safely assumed to be pre-Vedic: and as Śramaṇism reveals a radically different type of mind than that of the authors and the adherents of the Vedic religion, it may be further assumed that the order originated among the pre-Aryan people. According to the Jain and the Buddhist texts, the śramaṇas of these orders practised self-mortification *and dhyāna* (meditation) in two different postures, sitting and standing. The posture of sitting for *dhyāna* is known as *pallaṅka* or *paryaṅka* (bed-stead), *āsana* (posture), when one sits crossed-legged with the palms of the hands placed one upon another on the lap, holding chest, neck and head erect and eyes fixed on the tip of the nose. All the seated images of the Jain Tīrthaṅkaras dating from about the beginning of the Christian era are exactly in this posture, and almost all the seated images of the Buddha are partially in this posture with hands posed in different ways. In the standing posture of *dhyāna* called the *kāyotsarga* (dedication of the body) one is required to stand erect with both the arms hanging on sides and eyes fixed on the tip of the nose. All the standing images of the Jain Tīrthaṅkaras are in this posture. In Sir John Marshall's *Mohenjo-daro and the Indus Civilization*, on Plate XII, Figures 13-14, 18-19, and 22 are reproduced five seals each showing a human figure in *kāyotsarga* posture. The standing figure, in Figs. 13, 15, and 19, stands within what looks like a decorated arched doorway evidently representing a temple. The image in Fig. 18 has on two sides two plants growing together from the centre of a flower or a circular plot below, and the image in Fig. 22 stands between two trees growing apart. Each of these last two figures has got a trident on the head. All these five standing figures are naked. This feature is clearly brought out in Fig. 18 where in the lower register there are seven duly clad figures walking in procession. Figs. 18, 19, and 22 show a half-kneeling votary and a humpless bull with two horns in front of the standing figure. These figures representing images intended for worship closely resemble the Jina Ṛiṣabha, the first of the twenty-four Tīrthaṅkaras of the Jains, who has a bull for his symbol. Any way, these seals with figures standing in the pose of meditation bear witness to the existence of Śramaṇism or the cult of the śramaṇa that may be recognized as the proto-type of Jainism in the Indus Valley about 3000 B.C.

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[1] Macdonell, *The Vedic Mythology.*

Seated figures on some of the seals found at Harappa and Mohenjo-daro also point to a similar conclusion. One of these on a seal reproduced on the same Plate (XII) of Sir John Marshall's book, a four-faced deity surrounded by beasts and rightly recognized by Sir John Marshall as the proto-type of Śiva, is seated in a posture closely resembling the *pallaṅka* posture. Human figures seated in the same posture are also found on other seals unearthed at Harappa and Mohenjo-daro. A soap-stone fragmentary statuette of which the head and part of the left shoulder only are preserved, shows another element invariably found in the later images of the Buddha and the Tīrthaṅkaras, the eyes fixed on the tip of the nose (*Mohenjo-daro and the Indus civilization*, Pl. XCVIII). What do these figures posed as the later *Yogins* represent? Do they represent śramaṇas like Gautama Buddha and Jina Mahāvīra who showed the path of attaining supreme knowledge? Jaina tradition has handed down the names of twenty-three predecessors of the last Tīrthaṅkara Mahāvīra who was a contemporary of Gautama Buddha, the first among whom, Ṛiṣabha, is said to have lived millions of years ago. The Pali Canon (Mahāpadāna Sutta of the Dīgha Nikāya) and the inscription on the ground rail of the stūpa of Bharhut contain the names of six predecessors of Gautama Buddha, the first of whom, Vipaśvin, is said to have lived as many years before. This immense antiquity ascribed to the legendary founders of Jainism and Buddhism indicate that the traditions of these sects assigned the beginnings of Śramaṇism to a very remote antiquity.

What were these beginnings? The seals of Mohenjo-daro and Harappa do little more than indicate the antiquity of Śramaṇism. For guessing its beginnings we have to depend on late documents and analogies. We have already seen that

Megasthenes divides the śramaṇas into two classes, the Hylobii (hermits in the wood) and the physicians who by sorcery could cause people to have numerous offspring, and either male or female offspring. About the remedies used by the śramaṇas to cure diseases Megasthenes writes :—

'And that they cure diseases mostly through cereals, and not through means of medicaments; and that, among their medicaments, their ointments and their poultices are most esteemed, but that the rest of their remedies are bad' (Strabo. 15. 60).

Among the Śramaṇas Megasthenes includes 'diviners and enchanters, who are skilled both in the rites and in the customs pertaining to the deceased, and go about begging alms from village to village and from city to city'.

I have already quoted the statement of Āpastamba that the orders of the śramaṇas are declared most excellent by some on account of Vedic texts in their favour, and 'on account of the visible results'. As examples of 'visible results' Āpastamba states (2. 9. 23. 7-8) :—

'Now they accomplish also their wishes merely by conceiving them.

'For instance (the desire to procure rain), to bestow children, second-sight, to move quick as thought, and other (desires) of this description.'

Thus Āpastamba supports the statement of Megasthenes that the śramaṇas were sorcerers by profession. Megasthenes also states definitely that the śramaṇas were also physicians by profession, and his account shows that they were regularly trained physicians. Very probably the śramaṇas were sorcerers and medicinemen before they became the finders of the path of supreme knowledge. The brāhmans also began as performers of the magical or semi-magical sacrificial rites long before they grew into philosophers of the type of Uddālaka Āruṇi and Yājñavalkya. Primitive sorcerers of the Indus Valley probably practised self-mortification as an effective means of acquiring supernatural powers and their fits of endurance were considered miraculous by the common people. Śramaṇism began among the pre-Aryan folk of the Indus Valley with sorcerers and medicinemen who adopted the practice of renunciation and self-torture on account of their supposed magical property of procuring supernatural powers. At the time when we catch the first glimpse of the śramaṇas on the seals unearthed at Harappa and Mohenjo-daro, faith in them had grown so strong that the images of some of the śramaṇas were being worshipped even after their death probably to gain the objects for which they were consulted when alive. Among these objects happiness in life after death may have also been included in course of time, for worship of a śramaṇa who is dead shows faith in his being alive after death.

4. *Later History of Śramaṇism.*

Those who have kindly followed me so far will find that I have been piling hypothesis upon hypothesis to account for the origin of Śramaṇism. The basis of the hypothetical reconstruction that I have submitted to you is the hypothesis that Śramaṇism or the renunciation of the world and the practice of self-mortification even to death on the one hand, and Brāhmanism as taught in the Brāhmaṇa parts of the Vedas on the order, disclose radically different mental characteristics belonging to different psychological types. I have based this hypothesis on the pre-Mauryan history and the pre-history of Śramaṇism and Brāhmaṇism. The post-Mauryan history of these two creeds also point to a fundamental opposition between them justifying the assumption of their origin among peoples with radically different cultures.

In reply to the contention of Jaimini in the Vedāntasūtra 3. 4. 18 quoted above that scriptural passages (Upaniṣads) contain only references to the orders of the śramaṇas and no clear injunction, Śaṅkara states in the concluding portion of his commentary on this Sūtra :—

'But there is at any rate one scriptural text which directly and unambiguously enjoins the condition of life of the wandering mendicant, viz. the one of the Jābālas, "Let him wander forth at once from the state of studentship".'

After this Śaṅkara says on behalf of the supporter of Jaimini :—

'True, but our discussion is carried on without reference to that passage.'

This means that neither Jaimini nor Bādarāyaṇa refers to this injunction of the Jābāla-Upaniṣad.

Again, in the concluding paragraph of his commentary on the Vedāntasūtra 3. 4. 20 which gives Bādarāyaṇa's reply to Jaimini Śaṅkara writes :—

'This whole discussion (between Jaimini and Bādarāyaṇa relating to the question whether there is any Upaniṣadic injunction in favour of the orders of the śramaṇas) has been carried on by the teacher without taking into account the text of the Jābālas, which enjoins the other stage (order) of life. But there exists that text which directly enjoins the other stage (order), "Having completed his studentship he is to become a householder; having been a householder he is to become a dweller in the forest; having been a dweller in the forest he is to wander forth; or else he may wander forth from the student's state; or from the house; or from the forest".' (Thibaut.)

Rāmānuja also, in his commentary on the same sūtra, admits that the passage from the Jābāla-Upaniṣad is not referred to in the original *Vedāntasūtras*. His remarks are very significant :—

'No account being taken of the texts of the Jābālas, "Having completed his studentship he is to become a householder", etc., it is thus a settled conclusion that the texts discussed, although primarily concerned with other topics, must at the same time be viewed as proving the validity of the several conditions (orders) of life. From this it follows that the text enjoining the Agnihotra up to the end of life, and similar texts, are not universally binding, but concern those only who do not retire from worldly life.' (Thibaut.)

No less historical value attaches to the remarks of Rāmānuja than to those of Śaṅkara, for the former follows the abridgements of the very old commentary of Bodhāyana. Now all these authorities agree in holding that the Jābāla-Upaniṣad is not referred to by Bādarāyaṇa even when a reference to it would have enabled him to silence the supporters of Jaimini. The only possible conclusion that may be drawn from this fact is that the Jābāla-Upaniṣad is not a genuine old Upaniṣad, and must have been composed after the compilation of the Vedāntasūtras when Śramaṇism had already overcome old Brāhmanism and considerably transformed it. The first stage in the development of this neo-Brāhmanism is found in the code of Manu who provides (6. 2), 'When a householder sees his (skin) wrinkled, and his (hair) white, and the sons of his sons, then he may resort to the forest'. Manu even provides suicide for the hermits in the wood (Vānaprastha) as an alternative course (6. 31-32) :—

'Or let him walk, fully determined and going straight on, in a north-easterly direction, subsisting on air and water, until his body sinks to rest.

'A brāhman, having got rid of his body by one of those modes practised by the great sages, is exalted in the world of Brahman, free from sorrow and fear.'[1]

According to Manu's commentator Medhātithi the different modes of getting rid of the body are, 'drowning oneself in a river, precipitating oneself from a mount, burning oneself, or starving oneself to death'.

The next stage in the history of Brāhmanism after this compromise with Śramaṇism is marked by the ascendancy gained by the Vaiṣṇava and the Śaiva cults early known as Pāñcarātra and Pāśupata. These cults belong to the path of *Bhakti* (love of personal God) as distinguished from the *Karmakāṇḍa*, religious works or Vedic rites. The Pāñcarātra and the Pāśupata are first given prominence in the *Mahābhārata*, Book 12. In one stanza (12. 35. 1. 6) it is said :—

'O royal sage, let it be known to you that Sāṅkhya, Yoga,

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[1] English translation by Bühler, *Sacred Books of the East*, Vol. XXV.

Pāñcarātra, the Vedas, and the Pāśupata are the branches of knowledge that teach divergent views '.[1]

Here Sāṅkhya, Yoga, Pāñcarātra, and Pāśupata are placed on the same footing as the Vedas as independent branches of knowledge. In another stanza quoted by Aparāditya in his commentary on the *Yājñavalkya-smṛiti* called *Aparārka* (1. 7) it is said :—

'Sāṅkhya, Yoga, Pāñcarātra, the Vedas, and Pāśupata are supremely authoritative : so they should not be subjected to criticism.'[2]

The Śaiva and the Vaiṣṇava cults are also advocated in the Purāṇas. But in spite of the advocacy of the Mahābhārata and the Purāṇas, orthodox Smārtas considered Śaivism and Vaiṣṇavism, like Buddhism and Jainism, external (*vāhya*) or non-Vedic (*Veda-vāhya*) systems. This stanza of Vyāsa (from the *Vyāsa-smṛiti*) is quoted by Aparāditya (1-7) and Halāyudha (*Brāhmaṇa-sarvasva*) :—

'Therefore what is learnt from the Veda is the most excellent *dharma*, and what is taught in the Purāṇas and other texts is inferior.'[3]

The followers of the external cults are declared untouchable in the following passage of an old digest of the Dharmaśāstras called the *Caturviṁśatimatasaṁgraha* quoted by Mādhava in his commentary on the *Parāśarasmṛiti* :—

'On touching the Buddhists, the Pāśupatas, the Jains, the Lokāyatikas, the Kāpilas, and twice-born men who do not perform their proper rites one should plunge in water with his clothes : on touching the Kāpālikas he should perform *prāṇāyāma* (suppression of breath) in addition.'[4]

The Lokāyatikas were nihilists ; the Kāpilas were evidently śramaṇas who followed the Sāṅkhya system : the Kāpālikas are the Śākta śramaṇas who worship the Devī or the mother goddess. Aparāditya quotes this stanza from another Smṛiti (*smṛityantara*) :—

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[1] साङ्ख्यं योगं पाञ्चरात्रं वेदाः पाशुपतन्तथा ।
ज्ञानान्येतानि राजर्षे विद्धि नानामतानि वै ॥

[2] साङ्ख्यं योगं पाञ्चरात्रं वेदाः पाशुपतं तथा ।
अतिप्रमाणान्येतानि हेतुभिर्न विचारयेत् ॥
(Ānandāśrama series, No. 46, p. 11.)

[3] अतः स परमो धर्मो यो वेदादधिगम्यते
अवरः स तु विज्ञेयो यः पुराणादिषु स्मृतः ॥

[4] बौद्धान् पाशुपतान् जैनान् लोकायतिक-कपिलान् ।
विकर्मस्थान् द्विजान् स्पृष्ट्वा सचेलो जलमाविशेत् ॥
कापालिकांस्तु संस्पृश्य प्राणायामोऽधिको मतः ॥
(Bib. Ind., Vol. I, p. 259.)

'On seeing the Kāpālikas, the Pāśupatas, the Śaivas, and the artisans one should look at the sun, and on touching them one should bathe.'[1]

The reason for this hostility of the Smārtas to all but the Vedic religion is explained in this stanza quoted by Aparāditya and attributed by him to his teachers :—

'The system that has been created by a personal author should not be followed ; that is not authoritative, because that originated in the mind of a person.'[2]

Sāṅkhya, Yoga, Śaiva, Vaiṣṇava, Jaina, Bauddha, and Śākta systems are attributed to authors, whether human or superhuman, but the Vedas are authorless (*apauruṣeya*) and self-existent, and, therefore of far greater authority according to the *Smārtas* and the *Mīmāṁsakas.* Sir John Marshall has produced sufficient evidence to show that Śaivism originated in the Indus Valley in the prehistoric period. Vaiṣṇavism in its original form, Pāñcāratra, was the cult of the Yādava (Kṣatriya) heroes, Vāsudeva (Kṛiṣṇa), Saṅkarṣaṇa, Pradyamṇa, and Aniruddha. I shall presently deal with Śaktism. These religions of *bhakti* broke the backbone of old Brāhmanism by the conversion of the brāhman householders who began to perform the *pujā* (worship) of the Purāṇic deities instead of Vedic *yajñas* (sacrifices).

Like the code of Manu and other later Smṛitis, the Purāṇas also prescribe, not only the renunciation of the world, but also the renunciation of life, probably both for householders and Yatis. In some passages of the *Kūrmapurāṇa* quoted by Mādhava in his commentary on the *Parāśara-smṛiti* (12. 58) suicide at holy places is declared meritorious. Thus it is said of suicide at Somatīrtha on the Narmadā :—

'O King ! a man who (commits suicide by) entering fire, plunging in water, or fasting at Somatīrtha (on the Narmadā) is not born again.'[3]

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[1] कापालिकान् पाशुपतान् शैवांश्च सह कारुकैः ।
दृष्ट्वाचेद्रविमीचेत स्पृष्ट्वाचेत् स्नानमाचरेत् ॥

[2] अनुष्ठेयं न भवति यच्छास्त्रं पुरुषः कृतम् ।
तदप्रमाणं विज्ञेयं पुंबुद्धिप्रभवं हि तत् ॥

[3] अग्निप्रवेशं यः कुर्य्यात् सोमतीर्थे नराधिप ।
जले वा नाशके वापि नासौ मर्त्योऽभिजायते ॥

Again it is said of those who commit suicide at Prayāga (Allahabad) :—

'(When) one having a whole body, being free from disease and possessing the five organs of sensation, enters fire prepared with dry cow-dung as fuel, in the area between the Ganges and the Jumna (at Allahabad), thrives in heaven for as many hundred thousand years as there are holes for hair on his body; one who drowns himself at the famous junction (of the Ganges and the Jumna) during the lunar eclipse (lit., "when Rahu devours the moon"), freed from all sins, reaches the world of the moon and enjoys pleasures with moon.'[1]

Suicide by one suffering from an incurable disease is declared meritorious in the following passage of the *Āditya-purāṇa* quoted by Mādhava (on *Parāśara-smṛiti*, 3. 10) :—

'If a man suffering from a serious incurable disease throws himself into burning flame, or fasts, or throws himself into deep water, or falls from a precipice, or eagerly proceeds on the last journey towards snow-clad mountain, or dies on (hangs himself from) the branch of the banyan tree at Prayāga reaches excellent worlds, and is not an (ordinary) self-murderer.'[2]

Even after the supersession of the Vedic religion of sacrificial rites by the Purāṇic Śaivism and Vaiṣṇavism, and the sanction given by the later *Smṛitis* to the orders of the hermits in the wood and Yatis or religious mendicants, the old Brāhmanic love of life endeavoured to reassert itself by declaring that though entrance into these orders might have been permissible in the earlier *yugas* or ages (*Satya*, *Tretā*, and *Dvāpara*), it is not permissible in the present *Kali* age. Aparāditya quotes the following stanza from an unnamed Smriti (*Smaranti*) in the *Aparārka* (on the *Yājñavalkya-smṛiti* 1, 156) :—

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[1] गङ्गायमुनयोर्मध्ये करीषाग्निं विशेत्तु यः ।
अहीनाङ्गो ह्यरोगश्च पञ्चेन्द्रियसमन्वितः ॥
यावन्ति रोमकूपानि तस्य गात्रेषु मानवः ।
तावद्वर्षसहस्राणि स्वर्गलोके महीयते ॥
जलप्रवेशं यः कुर्य्यात् सङ्गमे लोकविश्रुते ।
राहुग्रस्ते यदा सोमे विमुक्तः सर्व्वपातकैः ।
सोमलोकमवाप्नोति सोमेन सह मोदते ॥

[2] दुश्चिकित्स्यै-र्महारोगैः पीड़ितस्तु पुमान् यदि ।
प्रविशेज्ज्वलनं दीप्तं कुर्य्यादनशनं तथा ॥
अगाधतोयराशिं वा भृगोः पतनमेव वा ।
गच्छेन्महापथं वापि तुषारगिरिमादरात् ॥
प्रयागवटशाखायां देहत्यागं करोति वा ।
उत्तमानाप्नुयाल्लोकान् नात्मघाती भवेत् क्वचित् ॥

'Sacrifice of cow, raising son (on a widow) by deceased husband's younger brother, sacrificial session (lasting over twelve days), carrying *kamaṇḍalu* (water vessel), drinking wine, entering the order of bhikṣus (religious mendicants), should not be practised in the Kali age.'[1]

Aparāka was compiled in the twelfth century A.D. Raghunandana (in the sixteenth century) quotes this passage in his *Udvāhatatva* from the *Bṛihan-Nārdiya-Purāṇa*, which is a Mahāpurāṇa :—

'Sea voyage ("to die" adds the scholiast Kāśirām), carrying Kamaṇḍalu (filled with water), marrying maidens of different castes by twice-born men, (widow's) producing son by husband's younger brother, killing cow for entertaining guest, offering beef in the funeral ceremony, entering the order of hermits in the wood (*vānaprastha*), giving away to a bridegroom a daughter already married, continuing for long as a Vedic student, performance of human sacrifice and horse sacrifice, starting on the last journey (*mahāprasthāna*), cow sacrifice—wise men declare that these *dharmas* (usages) should not be practised in the Kali age.'[2]

A passage containing a longer list of usages forbidden in the Kali age is quoted from the *Āditya Purāṇa* by Hemādri in his *Caturvargacintāmaṇi* and by the compilers of other standard digests of Hindu law and usage including Raghunandana. I shall reproduce a few lines from this passage :—

'Entrance into the order of hermit in the wood in accordance with rules, shortening the period of impurity on account of occupation and Vedic studies, prescribing expiatory rites for brāhmans ending in death, ... employment of Śudras for cooking the food of the brāhmans and others, (committing suicide by) falling from the precipice and throwing oneself into fire..........these usages have been deliberately forbidden by the high-souled sages in the beginning of the Kali age for the protection of mankind.'[1]

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[1] गोपशुं देवरात् पुत्रं सत्रयागं कमण्डलुम् ।
सुराप्रयोगं भिक्षुं च न कुर्वीत कलौ युगे ॥

[2] समुद्रयात्रास्वीकारः कमण्डलुविधारणं ।
द्विजानामसवर्णासु कन्यासूपयमस्तथा ॥
देवरेण सुतोत्पत्ति मधुपर्के पशोर्व्वधः ।
मांसदानं तथा श्राद्धे वानप्रस्थाश्रमस्तथा ॥
दत्तायाश्चैव कन्यायाः पुनर्दानं वरस्य च ।
दीर्घकालं ब्रह्मचर्य्यं नरमेधाश्वमेधकौ ॥
महाप्रस्थानगमन गोमधश्च तथा मखं ।
इमान् धर्म्मान् कलियुगे वर्ज्यानाहुर्मनीषिणः

Hemādri compiled his *Caturvargacintāmaṇi* between A.D. 1260 and 1270. It is difficult to determine the date when and the place where the Āditya-Purāṇa, the Brihan-Nāradīya-Purāṇa, and the Smṛiti text quoted by Aparāditya on the Kali *dharma* were compiled. But after the rise of Śaṅkara in the eighth century A.D. Śramaṇism gained ascendancy among the Brāhmanists. Śaṅkara organized the Brāhmanic order of the Dandī-Sanyāsis which still survives. and in his voluminous writings,—the commentaries on the oldest Upaniṣads, the Vedāntasūtras, and the Bhagavadgītā, insists that *mokṣa* can be only gained by the possession of the knowledge of Brāhman-Atman, and the only way to gain this knowledge is the renunciation of the world and adoption of the life of a religious mendicant. The ostensible object of the Bhagavadgītā is to persuade Arjuna to perform the duties of a Kṣatriya householder. The older commentators evidently interpreted the *Gītā* in that light. Śaṅkara in the beginning of his commentary on the Gītā thus explains their views :—

'Some people say, one cannot obtain salvation (lit. final isolation) by renouncing all the sacred duties of the householder and pursuing the knowledge of Ātman (self). Then what (should be done) ? The settled meaning of the Gītā is that salvation is gained by the knowledge of Ātman along with the performance of Agnihotra and other rites prescribed in the Sruti (Veda) and Smṛiti.'

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[1] वानप्रस्थाश्रमस्यापि प्रवेशो विधिचोदितः ॥
वृत्त-स्वाध्यायसापेक्षमघसङ्कोचनं तथा ।
प्रायश्चित्तविधानं च विप्राणां मरणान्तिकम् ।

* * * * *

ब्राह्मणादिषु शूद्रस्य पचनादिक्रियापि च ।
भृग्वग्निपतनञ्चैव वृद्धादिमरणं तथा ॥

* * * * *

एतानि लोकगुप्त्यर्थं कलेरादौ महात्मभिः ।
निवर्त्तितानि कर्म्माणि ।

This view of the teachings of the Gītā is known as the *jñāna-karma-samūccayavāda*, the doctrine of the combination of the performance of the sacred duties of the householder with the pursuit of the knowledge of Ātman. Śaṅkara rejects this interpretation of the Gītā which is identical with Jaimini's view regarding the teachings of the Upaniṣads or Vedānta, and affirms that according to the Gītā renunciation of the duties of the householder is absolutely necessary for gaining that knowledge which leads to *mokṣa*.

Since the days of Śaṅkara the Vedāntasūtra of Bādarāyaṇa has been made the basis of the teachings of almost all the brāhman religious reformers whether Vaiṣṇava or Śaiva, and Śramaṇism is now established as the crowning member of the edifice of Hinduism. Of course, very few people are capable of renouncing the world; but the ideal of Śramaṇism—renunciation of all possessions, renunciation of the pleasures of life, adoption of the yellow robe, is held in the highest veneration by the Hindus. It is now believed by the Hindus in general that *siddhi*, the attainment of the highest goal of spiritual life, is only possible for a *Sādhu* or *Sanyāsī*, and a dutiful and pious Sanyāsī is recognized as a *Siddha*, one who has reached the goal, and adored as the divinity.

5. *The Śāktas and the Vaiṣṇavas of Bengal.*

There is, or until very recently there was, one exceptional Hindu sect. The Śāktas of Bengal do not recognize the renunciation as absolutely necessary for gaining *mokṣa*. The following stanza from the *Rudra-yāmala-Tantra* is quoted by Brahmānandagiri in his *Śāktānandataraṅginī*:—

'Where there is enjoyment of pleasures, there *mokṣa* (salvation) is not obtainable: where there is (pursuit of) *mokṣa*, there pleasures of life are not available; but (both) pleasures of life and *mokṣa* are in possession of those who worship the pair of the lotus feet of the consort of Śiva.'[1]

Like the followers of the Vedic religion the Śāktas also sacrifice animals—goat and buffalo, to Durgā and Kali, and offer *surā* (wine) to the latter goddess. Though there was an order of Śākta Sanyāsīs called Avadhūtas in Bengal, they were neither numerous nor influential. Krisṇānanda in the *Tantrasāra* quotes passages from Tantrik texts that enjoin that the religious preceptor (*guru*) of the Śākta should be a duly qualified householder (*āśramī* or *grihastha*).

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[1] यत्रास्ति भोगो न च तत्र मोक्षो
यत्रास्ति मोक्षो न च तत्र भोगो ।
शिवापदाम्भोजयुगार्च्चकानां
भोगश्च मोक्षश्च करस्थ एव ॥

The modern Vaiṣṇavas of Bengal who adore Caitanya (A.D. 1485–1522) as an incarnation of Viṣṇu follow the Tantrik injunctions so far as they are reconcilable to the teachings of the *Bhāgavata-Purāṇa*. Though Caitanya himself was a Sanyāsī, his chief disciples, Advaita and Nityānanda, who propagated his religion, were not. The latter was an Avadhūta in his early life, but later on married and founded a well-known family (*parivāra*) of Gosains (Gosvāsmīs) or hereditary preceptors (*gurus*). In the *Haribhaktivilāsa*, a digest on the rites and usages of the Vaiṣṇavas of Bengal compiled by Gopāla-Bhaṭṭa (Book 1) texts are quoted that enjoin that the *guru* must be a *grihastha* (householder). Among the followers of Caitanya there is an order of Vaiṣṇava mendicants, mostly recruited from the lower ranks of society, who do not observe celibacy and who are known as Baistabs or Baistams and Bābājis. But these Bābājis do not command the influence of the Gosains who are all householders and trace their descent from one or other of the leading followers of Caitanya. In the concluding section of the *Haribhaktivilāsa* (Book 20) Gopāla-Bhaṭṭa writes :—

'Though there are many excellent rites prescribed by the scripture, all of them are not described here, because there are no people who practise them. The rites and usages described in this work are mostly intended for virtuous and wealthy householders ; nothing has been written about the Mahātmās who renounce the world. To gain the same end (*mokṣa*) they (Sanyāsīs) also should perform the duties prescribed above, for the performance of pious duties is the only way to acquire *bhakti* (loving faith in God).'[1]

Gopāla-Bhaṭṭa then quotes certain stanzas from the *Bhāgavata-Purāṇa*, the *Brahmavaivarta-Purāṇa*, and the *Viṣṇu-rahasya* wherein it is stated that an *Ekāntibhakta*, an extreme devotee of Viṣṇu, who renounces the world may reach the goal even without performing the rites and duties incumbent on a householder. But this very short section on 'the extreme devotee' is intended only to give completeness to the work.

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[1] सन्त्यन्येऽपि सदाचारा बहवः शास्त्रदर्शिताः ।
न लिख्यन्तेऽत्र ते सर्व्वे ग्राहकाभावतोऽधुना ॥
कृत्यान्येतानि तु प्रायो गृहिणां धनिनां सताम् ।
लिखितानि न तु त्यक्त परिग्रह महात्मनाम् ॥
अवश्यं तानि सर्व्वाणि तेषां तादृकत्वसिद्धये ।
प्रागपेक्ष्याणि भक्तिर्हि सदाचारैकसाधना ॥

The trend of the Śākta and Vaiṣṇava literature of Bengal is to give preference to the performance of the religious rites and duties incumbent on a householder while enjoying the legitimate pleasures of life. In the opinion of the strict followers of *bhakti* the way to attain *mokṣa* is not knowledge (*jñāna*), but *bhakti*. Gopāla-Bhaṭṭa teaches *bhakti-karma-samūnccaya*, the combination of the performance of religious rites like the dedication of temple, installation of image and so forth with the pursuit of *bhakti*.

6. *The Indo-Alpines.*

This peculiarity of the Bengali psychology, this ingrained love of life disclosed by their religions, Śāktism and Vaiṣṇavism, comparable only to the love of life of the Vedic Aryans, cannot be attributed to education or environment, but should be recognized as a racial psychological trait. This peculiar psychological trait is associated with a peculiar physical trait, brachycephaly or broadheadedness. From Risley's measurements it is evident 'that the degree of brachycephaly in the Bengali castes decreases from brāhman downwards if we except the Mongoloid groups like the Maghs'.[1] Dr. B. S. Guha, the Anthropologist of the Zoological Survey of India, who has measured several Bengali castes in connection with the last Census operations, has kindly informed me that his figures also point to the same conclusion on the whole. This broadheadedness distinguishes the Bengalis from the population of the rest of Āryāvarta or Northern India. But the same trait is found in the population of the part of the Deccan and of Gujarat who, together with the Bengalis, make up the middle zone. The common origin of these peoples and their affinity with the Alpine race of Western Asia and Europe pointed out by me is now recognized by most authorities. What was the original culture of the Indo-Alpines—their speech and their religion? Dr. Hutton says, 'It is not improbable that these Alpines had acquired an Indo-European language'[2] before invading India, that is to say, they were Aryan in speech. Among the Indo-Alpines the Bengalis are furthest removed from the centre of diffusion (Pamirs), and, in their religion, Śāktism, retain a singular cultural trait. All Hindus are, as a rule, worshippers of the five deities, viz. Āditya (sun-god), Gaṇa-nātha (Gaṇeṣa), Devī (goddess Durgā), Rudra (Śiva), and Keśava (Viṣṇu). The worship of these five deities are prescribed in connection with all ceremonies.[3] There are or were six different branches of the path of Bhakti according to a stanza quoted by Mādhava in his commentary on the *Parāśarasmṛiti* from *Purāṇsāra*. These branches, called *darśaṇas*, systems, are Śaiva, Vaiṣṇava, Śākta, Saura, Vaināyaka, and Skānda.[1] To a Śaiva Śiva is the head of the five deities or the Supreme Being: to a Vaiṣṇava Viṣṇu occupies that position: and to a Śākta the Śakti or the Devī (goddess) does so.[2] With the exception of the Devī all others are male deities. The Śāktas or special worshippers of the Devī are now met with among the higher caste Hindus of Bengal and Mithilā only. The Devī or Durgā is worshipped all over India during the first nine days (*navarātra*) of the bright half of Chaitra and Āśvin. But in Bengal the Goddess is worshipped with the greatest pomp. Other manifestations of the Devī are also regularly worshipped in Bengal. The Nepalese and the Tibetan Buddhist manuscripts indicate that it was probably in Bengal that the cult of Tārā and Tantrik rites were linked to Mahayāna Buddhism. In Bengal the cult of the Devī has been undergoing development even in recent times. After Durgā the most popular form of the Devī worshipped in Bengal is Kālī who should not be confounded with Kālī or Chamuṇḍā of the *Devīmāhātmya*. Wherever, outside Bengal, the Bengalis sojourned in the nineteenth century as Government employees, they established a house or temple of Kālī. According to tradition among the Śāktas of Bengal the worship of this grim form of the Devī was started by Kṛiṣṇānanda Āgamavāgīṣa in the sixteenth century. The archaic features in the worship of the Devī, sacrifice of goat and buffalo, and offering of wine, indicate the antiquity of the cult. It may, therefore, be assumed that the Indo-Alpines entered India with the cult of the Mother Goddess which still survives among the easternmost branch of that race, the Bengalis. Protected by the Devī, the Bengalis long resisted the attack of Śramaṇism. But the educated Bengalis are now abandoning the faith of their ancestors and, instead of the family *gurus* or religious preceptors, they are seeking initiation from *Sādhus*, the modern representatives of the ancient śramaṇas, and, very recently, influential monastic orders have been started by educated Bengali Sanyāsis. Such a change must have happened among the Vedic Aryans in the North and among the Gujaratis and the Deccanese in the South long long ago.

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[1] Hutton, *Census of India*, 1931, *Report*, p. 457.

[2] Hutton, *op. cit.*, p. 368.

[3] आदित्यं गणनाथं च देवीं रुद्रं च केशवम् ।
पंचदैवतमित्युक्तं सर्वकर्मसु पूजयेत् ॥

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[1] शैवञ्च वैष्णवं शाक्तं सौरं वैनायकन्तथा ।
स्कान्दञ्च भक्तिमार्गस्य दर्शनानि षडेव हि ॥

[2] The Saura worships Sūrya (sun-god) as the Supreme Being, the Vaināyaka worships Vināyaka (Gaṇeṣa) as the Supreme Being, and the Skānda worships Skanda (Kārttikeya) as the Supreme Being. Followers of these three sects are now rare.

7. *Conclusion.*

I shall now conclude this lengthy address with a few remarks on the good and the evil consequences of Śramaṇism. The greatest contribution that Śramaṇism has made to the culture of India is the Indian philosophy. According to the Hindus. knowledge is to be acquired not only by thinking, but by practising asceticism and meditation. Indian art also owes its inspiration to a considerable extent to Śramaṇism. But while aiding the building up of the civilization, Śramaṇism generated toxins in the social organism that undermined its health. In a stanza from a Purāṇa quoted above from Āpastamba's Dharmasūtra it is said that those eighty-eight thousand Ṛiṣis (sages) who desired no offspring obtained immortality. The Ṛiṣis who desired no offspring and could renounce the world for the pursuit of knowledge were undoubtedly ahead of their community both morally and intellectually. But their dying without issue for hundreds of generations resulted in the gradual elimination of the best elements of the population and thereby contributed to the decline of the Hindus.

Section of Anthropology.

Abstracts.

1. Some observations on the Fijian hair.

R. N. BASU *and* J. K. GAN, Calcutta.

(*Communicated by Dr. P. Mitra, Calcutta University.*)

This paper deals with the cross-sections, pigmentation, etc., of the samples of hair collected by Dr. P. Mitra from Fiji Islands in 1929.

2. The Nokrom System of the Garos.

J. K. BOSE, Calcutta.

(*Communicated by Dr. P. Mitra, Calcutta University.*)

The most complicated system in the Garo social organization is the 'Nokrom System'. In Garo language, 'nok' means house, and 'krong' means post, that is 'Nokrom' is the house post or the support of the house. 'Nokrom' is the son-in-law of the family and is selected from one of the sons of the man's sisters. But there is also another kind of son-in-law known as 'Chowari'. These two types of son-in-law can be distinguished from their rights and privileges. 'Chowari' has no right or control over the property of his father-in-law and he has to build a separate house for his family. On the other hand the 'Nokrom' lives in the same house with his parents-in-law and after the death of his father-in-law, becomes the owner of the house and of the property. But another important obligation placed on the shoulder of the 'Nokrom' after the death of his father-in-law is that he is bound to marry his mother-in-law, that is his mother's brother's wife. In some cases complications rise to its extreme by the birth of a daughter of the mother-in-law by the 'Nokrom' and the presence of a former daughter by the Nokrom's wife. In all these cases a settlement is reached by the intervention of the village elders.

3. The Umanglai Spirits of the Meiteis (Manipuris).

S. J. SINGH, Imphal.

(*Communicated by Dr. P. Mitra, Calcutta University.*)

Besides a Supreme Being (Taibangpangba-gi-mapu) the Meiteis have a definite class of Superior Beings (Lais). They are not mere animistic conceptions, nor shade off into Nature gods; rather they have definite social co-relations. The seven patrilineal Salais or sibs are associated with seven goddesses who along with nine other gods are classified as Umanglais and stand next to the Supreme Being. Last of all comes the household deity or Imunglai. Hodson's classification seems to have been due to two errors. He was misled by the Meitei word *pokpa* which means born of and created the Salai ancestors by the addition of the word *pokpa* which is not warranted by Meitei traditions. Further, his classification of Umanglais, forest Lamlai, and tribal Sagailai into distinct group is also not corroborated by Meitei tradition which includes them all under Umanglai.

4. The Koches of North Bengal.

N. C. SEN.

The origin of the word Koch. The distribution of the Koch. Their material culture (habitations, house, utensils, dress, food, agriculture, fishing). Terms of relationship. Social organization. Life history (Birth, Names, Puberty and Initiation). Marriage (Forms of marriage, Preliminaries to marriage, Marriage ceremonies, Divorce). Death and disposal of the dead (Treatment of the dead, Grave goods, Ceremonies at death). Agricultural ceremonies. Religious ceremonies.

5. The Lapchas of Sikhim.

P. C. BISWAS, Calcutta.

(Communicated by Dr. P. Mitra, Calcutta University.)

According to their own tradition, the Lapchas were on the Mount Everest whence they came to Sikhim; they say they have borrowed the language of the Sikhimite. They are divided into eight endogamous clans. To marry a blood-relation is strictly prohibited. The Lapchas have a belief that mother's relations are much nearer than the father's. Maternal uncle's permission is essential in the performance of the marriage. The binding portion of the ceremony is marriage feast. Widow remarriage occurs among them. Divorce is also customary among them. They have got no puberty ceremony, only they observe certain tabus. No childbirth ceremony is observed among them. Originally the Lapchas practised burial system, but now both burial and burning are in vogue. The present religion of the Lapchas is Buddhism, but it is clear that a pre-Buddhist religion is not entirely dead.

6. Studies in pulse and respiration rates among the Bengalis.

R. N. BASU, Calcutta.

(Communicated by Dr. P. Mitra, Calcutta University.)

In this paper an attempt has been made to find out, after taking data from 500 individuals, the average rate among the Bengalis. A critical comparative study with the peoples of other provinces in India is given.

7. Kepmaris—an ethnological study of one of the criminal tribes of Mysore.

L. K. ANANTHAKRISHNA IYER, Calcutta.

Origin and history of the tribe. Their habitat. Their pseudo-names. Their habits and customs. Their omens and superstitions. Their thieving propensities. Their disguises on record. Their present conditions.

8. Worship of Mother Earth—its origin and development.

L. K. ANANTHAKRISHNA IYER, Calcutta.

9. Village organization of the Aimol Kukis.

J. K. BOSE *and* NIRMAL CHAKRAVERTI, Calcutta.

(Communicated by Dr. P. Mitra, Calcutta University.)

The old village organization undergoes numerous changes in its composition under the influence of the superior culture of the Manipuris.

For the convenience of the Metei State they introduce some new officers in the village council and the people are bound to obey the mandates of those officers. The authority of the village chief is curbed in criminal cases and nowadays he has to remain satisfied in controlling the people in social and religious affairs, though petty cases within the village are always tried by him.

10. Physical measurements and descriptive observations of the Nulia fishermen of Puri.

H. C. Chakladar, Calcutta.

Thirty direct measurements have been taken, 13 on the head, 16 on the trunk and limbs besides the body-weight. In addition 25 descriptive observations have been made on the skin, hair, eye, ear, nose, lips, teeth, chin, etc. Four extra measurements and 12 indices have been calculated from the above data.

11. Some ritual songs of the Waralis, an aboriginal tribe.

K. J. Save.

The author gives a brief description of the Waralis, an aboriginal tribe, living in the Thana district of the Bombay Presidency, who speak a language which is a dialect of Marathi.

Among the ceremonies that these Waralis perform, marriage is the most important. They have their own priests in their marriage who are women. The 'Bhavaleris' as they are called, sing marriage songs. Out of these songs the author gives the substance of two here.

(1) The song of the betrothal:—Naran Barambha and Hemai (two of the Warali gods) started to select a bride. Hemai, the goddess was well dressed. They first went to the country of the 'Parabhas' and then to that of the 'Brahmins'. Naran Deva liked the girls in those countries. But Hemai opposed him saying that the girls were useless. At last they came to the country of the peasants and selected a peasant girl as the bride. This song tells that the Waralis love the life of a peasant.

There are many other songs sung by other women in the marriage. There is a romantic song in which a young woman blames her fate for not giving her a good husband and complaining that all his relations are not friendly towards her. There is another of this type, where a girl is pining for a good match. A song which describes a water-mill and the different plots in the garden gives us some idea about their life. There is a song in which the poet imagines that the Moon-light comes from the blossoming of the flowers on the skirts of the hill.

(2) Waralis scrupulously perform the ceremonies about the dead. Songs are an important part of these ceremonies. Out of these, one song describes the death of god Pandu. The goddess Earth began to weep because the land had become a great burden to her. So the gods decided that some creatures should die. Gods also were to be included in these mortals. But the Sun, the Moon, Wind, Rain, and some other gods proved that they were useful to the world. So they were dropped from the death-list. But god Pandu was of no use and he must die. When Pandu heard this, he was very much afraid. He went to god Issar, his brother-in-law and tried all means to avoid death. He hid beyond the seven seas. His children went to see him there. They took a plum with them, which they offered to him. But Pandu became nervous when he ate the plum and he was dead. There is a Mythological influence over this song. Pandu's death is described here because it is the mysterious death in the Hindu Mythology. When reading the plum incident, one is also reminded of the story of king Parikshita and Takshaka.

12. Ethnic affinities of the Deorukha Brahmins.

S. A. Nimkar, Bombay.

The Deorukhas, a sub-group of the Pancha-dravida group of Brahmins, are mostly found in the villages of the Sangameshwar and Ratnagiri Taluks of the Ratnagiri district. Though, many families have, for the last hundred and fifty years or so, been the residents of Malwa, Baroda and the Thana and Kolaba districts, their original home can be found in the Konkan. As to the origin of the word 'Deorukha' different theories are put forth by different writers. While some members of the caste like to explain their caste-name by referring to the word 'Devarig', meaning one who performs sacrifices, etc., others base it on the word 'Devarshi' as found in the Skanda-purana. But when, it is a well-known fact that people are named after the name of their habitat, and when a village 'Deorukh' around which, all the villages owned by the 'Deorukhas' are situated, exists in the above-mentioned tract, we can accept Enthoven's explanation that 'they take their name after the village Deorukh in the Sangameshwar Taluka of the Ratnagiri District', as reasonable and sufficient.

The anthropometrical measurements, skin colouring, and colouring of the eyes are described in the paper.

13. Animal remains from Harappa.

Baini Prashad, Calcutta.

The Archæological Survey of India excavated a large series of animal remains during the extensive excavations which were carried out at Harappa from 1924-25 to 1930-31. These have been studied by the author and found to consist of 4 species of Invertebrates and 26 Vertebrates. In the communication after enumerating the different species, the remains of which have been found at Harappa, attention is directed to the occurrence in the collection of the remains of Pariah dogs, two races of wild cattle, buffalo, donkey, rhinoceros, goat, sheep, pig, and camel. The question of the ancestries and centres of domestication of the different species is discussed, and reference is made to the fact that in the Indus Valley several species of animals seem to have been domesticated at a much earlier time than in the adjacent areas. Probably the Indus Valley served as a centre whence several of these species spread to the other parts of the world.

14. Social Organization of the Purum Kukis.

T. C. Das, Calcutta.

The Purums form a branch of the Old Kuki tribes of Assam. They possess some features of social organization which are specially interesting to the social anthropologist. A few of these (e.g. inter-clan relationship, marriage-grouping, etc.) is discussed from the author's personal knowledge.

15. The modern trend of primitive culture on the borders of Bengal.

T. C. Das, Calcutta.

An attempt is made in this paper to find out how far the primitive tribes living on the borders of Bengal have adopted Hinduism and why. The effect of contact with other proselytizing religions is also discussed at the same time.

16. Some sedentary games of Lower Bengal.

J. M. Datta, Calcutta.

(Communicated by G. P. Mazumdar.)

Some sedentary games of Lower Bengal, popularly known as Tānt-fānt, Lau-kāṭākāṭi, Bāgh-bandi, and Moghul-Pāthān. Diagrams and rules of games.

17. Ordeals amongst the Garos.

J. K. Bose, Calcutta.

(Communicated by Dr. P. Mitra, Calcutta University.)

Ordeals are still important in the Garo society and in all cases of disputes, ordeals are resorted to by the contending parties. In olden days there were numerous ordeals prevalent among them; but nowadays most of them have lost their former importance and become extinct. Some ordeals such as 'Chokhela', 'Akhrom', etc., which are still in vogue are described.

18. The Woan Gala Festival of the Garos.

J. K. Bose, Calcutta.

(Communicated by Dr. P. Mitra, Calcutta University.)

This is the only annual magico-religious festival among the Abeng Garos. It is generally held in November or December. The festival consists of two parts, one religious and the other social. The first part consists in the worship of the various godlings of the village by the village priest, and the second part of feasting, music, and dancing. It generally lasts from three to seven days according to the size of the village.

Section of Psychology.

President:—MANMATHANATH BANERJI, ESQ., M.SC., B.L.

Presidential Address.

APPLIED PSYCHOLOGY.

MR. PRESIDENT, LADIES, AND GENTLEMEN,

I am not going to give you any exposition of abstruse psychological principles, but I choose to speak on the present needs of India, needs which can only be solved by the application of Psychology in its different aspects.

PRESENT POSITION OF APPLIED PSYCHOLOGY.

The progress of Experimental Psychology and the Psychology Movement in India during the last 20 years is fresh before my mind's eye. It was in 1904 that the late Sir Asutosh Mukherji first introduced a course of study in Experimental Psychology into the B.Sc. and M.Sc. examinations of the Calcutta University. The first laboratory in India was started in 1916 and I was one of the staff. The Laboratory of Experimental Psychology was located in the then newly built University College of Science. Since then the department has silently worked in the cause of Psychology in the teeth of scholastic opposition from within and without and has grown up slowly. It has done a lot of spade work in popularizing scientific Psychology. It has been conducting a mental hygiene section in the annual Health Week Exhibition in the Indian Museum. Besides teaching and research, the department now conducts mental examination, free of charge, of any child or adult taken there for advice. It has trained students coming from the remotest corners of India.

Two All-India organizations—the Indian Psychoanalytical Society and the Indian Psychological Association—came into being in 1922 and 1926 respectively, the latter with its organ the Indian Journal of Psychology, almost entirely maintained by the University, has entered the ninth year of its life. This journal, the only one of its kind in India, has been recognized by its elder and maturer sisters abroad, though it has not as many subscribers in India as the Board of management would like to have.

The Indian Psychoanalytical Society affiliated to the International Psychoanalytical Association was founded by the present head of the department of Experimental Psychology, University College of Science, Calcutta, then a lecturer, in co-operation with his colleagues. The Society has been responsible for slowly disseminating the basic unconscious principles guiding human thought and action and the curative technique of modern Psychology, discovered by Prof. Freud—I mean Psycho-analysis—amongst mental sufferers and medical practitioners and the lay public. The starting of a Psychological Clinic in the Carmichael Medical College at Calcutta by the Head of the Department of Experimental Psychology under the patronage and financial assistance of his admirers was rendered possible last year.

The science of Psychology was recognized by the Indian Science Congress as one fit for deliberation and discussion only at its 11th Session. There is no denying of the fact that Experimental Psychology is the youngest of all experimental sciences but it seems that Psychology being the science of the mind which is the master and king of the body of man, the ruler of the phenomenal world, is *destined to play the most important* and predominating rôle in the conferring of happiness and in the welfare of mankind in the near future.

APPLICATION OF PSYCHOLOGY IN THE PAST.

There was a time when India led the whole world by her culture and learning founded on psychological concepts, propounded philosophies on the solid background of Psychology, applied psychological principles in evolving the social and religious fabric of the community. Indian physicians and the 'Smārtas' took ample help of Psychology for the alleviation of mental trouble ; the former devised measures for the treatment of diseases and the latter elaborated a system of expiations, daily prayers and occasional rituals for specific transgressions and diseases that were regarded as offshoots of sins. But during the period of Indian decadence, records of which almost exhaust the pages of history, all those psychological principles were reduced to mere systems of superstitions, forms being retained—the spirit evaporating. It is a debatable point whether India came to her political downfall owing to moral degeneracy or the downfall has been responsible for the moral and intellectual decadence. But there cannot be any doubt that the condition, so far as the intellectual advancement of the general population is concerned, is really lamentable. It is a patent fact that the spiritual and contented trend of the Indian culture has now almost lost its glamour for Indians. During centuries of chaos and ignorance, the people have undergone a change in their outlook on life. The binding forces of the social system—the castes and the stress on 'purity of stock'—have been loosened with the advent of modern science. A restless yearning for a higher standard of life and a greater demand for the advantages of modern civilization have replaced resignation to fate. The days of moral and religious advice to the mass to practise maitrī, karuṇā, muditā, and upekṣā are apparently gone. But the cardinal principles of training as embodied in the Yoga System of Pātañjali in the 33rd aphorisms of the Samādhi and Sādhana pādas are of eternal applicability irrespective of climate and the stock of man. They are

> Maitrī karuṇā muditopekṣāṇām
> sukha-duhkha-puṇyāpuṇya viṣayāṇām
> bhāvanātaścitta prasādanam.

The mind is purified by the practice of the ideals of happiness, sympathy, pleasure, and neutrality or indifference to others' pleasure, sorrow, good action, and bad action respectively. Vitarkavādhane pratipakṣa bhāvanam.—When there is the development of morally questionable ideas in mind such as jealousy, rage, ill-will, etc., they are to be checked by the development of opposite thoughts. Keen struggle for life, clamour for equality of rights and opportunities, jealousy and ambition are the keynotes of present advancement. The old fabric of culture and civilization is fast crumbling down and there is very little chance of resuscitating it again into life. The advanced nations now provide the model for the guidance of humanity.

THE FUTURE.

For the salvation of India, there is now no way out but to accept the applications and formulations of scientific research after modifying them to suit Indian social and communal conditions. There is authority for this sort of action. The great Hindu medical writer of the hoary past, Charaka said: Kṛtsno hi loko buddhimatāmācāryyah—'For the intelligent, the whole world is the teacher'. The intelligentsia have learnt something about the physical natural sciences, but the most important of all the natural sciences, the science of Psychology in its modern development, is known to a limited few. Many people know a little bit of the outlines of Classical Psychology of the West but few keep themselves abreast with the rapid strides that scientific psychology has made in the recent past. The psychologists of the West are trying to apply their knowledge for the advancement of every aspect of human life. Man has long neglected the organ of his intellect but the truth seems to have dawned at last and now eyes seem to be rivetted upon Psychology in the most advanced countries in the West. In every civilized country, attempts are being made to utilize the science of Psychology in practical life. *For the salvation of so vast a country as India a hundred times more extensive and intensive work on Psychology is necessary than is being done now. In India there is enough scope for hundreds of* *laboratories and Institutes, not necessarily in the universities and colleges only, but managed by outside agencies as well.*

As you all know, the claims of any science can only be tested by the range of its application. A pure science makes rapid strides when its application is brought to bear upon the practical needs of human beings. This has been the history in the development of every science and I see that the eldest and yet the youngest of all the sciences, Psychology is now entering this phase of development. Psychological knowledge has been requisitioned for the study of mental diseases, for education of the child, for the study of animal behaviour and for the control of the criminal but the most recent development has been its application to vocational guidance and selection and to industrial life. A pure science is only an intellectual recreation for the few who are seekers after knowledge but nothing is worth studying which has no pragmatic value in human welfare. Psychology, I can assure you, is the science *most needed of all the sciences in India at the present time for the cure of the evils* that have accumulated as the result of several mechanical, social, religious, and political revolutions, all having their roots in what we may say the economic disturbance of the people and ultimately *smothering the productive activity of man.* So it rests solely on you as exponents of Psychology to lead the people, the universities, the corporations, the industries, and the government to the right track, and I consider it my duty as President of this section to offer you my suggestions for your serious considerations. My experience leads me to emphasize the *two aspects of Applied Psychology*, viz., Vocational Guidance and Selection and Industrial Psychology. You will realize the Indian situation if you contrast it with the conditions obtaining in Western countries.

VOCATIONAL GUIDANCE.

In India, schoolmasters are supposed to go through an elementary course of Psychology, but they are mostly devoid of any training in the proper sense of the word. They are ill-paid and discontented. They eke out their income with working as private tutors. A vast majority of them are temperamentally unfit to act as teachers, so that the teaching throughout the country at the most important and critical period of a scholar's career suffers too lamentably to describe fully. True, there are B.T.s in inspecting staff who do the departmental supervision but this never effectively touches the pupil at the primary stage or his teachers. This is an important cause of the deterioration of the intellect of the youth of the country. The attention of the authorities seems to have been awakened to the physique of the student but not yet to the mind that presides over the body. Hardly two score of people in India really know how Psychology is utilized for the treatment of abnormal mental conditions in children.

In America, Europe, and Japan besides the tackling of the problems of the mentally diseased and the deficient, of the criminally disposed child and of finding out the best method of training children, psychological research is being utilized for what is known as vocational guidance. In India, the school authorities, the corporations, the Government departments of Education, Labour and Industries, and the universities do not think of giving any help to the adolescent boy or girl in the choice of careers. There is no idea of co-operation between the guardians of the scholars and the above-named bodies in this matter; it is only a concern of the former who only wake up one day to find that the future of the ward is a matter for considerable anxiety and it may be pointed out that the subject is of paramount significance in the welfare of the nation. But a boy or girl in London, for instance, after completing school career at the age of 15 has to face in company with his or her parent or guardian a committee consisting of the representatives of the Ministry of Labour, the Education and the Medical Officers of the London County Council, the headmaster or the headmistress and a psychological expert of the University of London for the purpose of vocational guidance. There are bureaus which keep accurate information about vacancies in the different industries. The vocational advisory committee and the bureau work together. The recent tendency in England is to put people trained in vocational psychology in charge of schools for boys or girls. For the lack of a system in India of well-considered proper vocational guidance for promising lads at the proper age, to the different avocations of life, by schools, district boards, corporations, universities, and the government throughout the country, *there is enormous waste of human material resulting in avoidable unemployment, economic deterioration and political unrest. All these require a thorough mental survey of the youth of the country after a proper estimation of the number that can be supported by the different professions and industries. It is necessary that every scholar should be given mental and scholastic tests, at least twice during his career and his personality tested to detect if anything went wrong, by one thoroughly trained in Experimental Psychology and Psychoanalysis.* There are about fifty different kinds of mental tests and various tests have been devised for testing the character, personality, talent, and temperament of candidates. These have to be improved and adapted to Indian conditions.

In England and America intensive efforts are made for vocational guidance in schools. It is the direct result of that colossal experiment in Psychology done in the United States of America and never before attempted elsewhere, for finding out men suitable for different grades of service in the Army. The experiment was conducted on nearly 1·75 million men with great success. This experiment also helped to select men for their avocations when they were obliged to serve in the Army. So the war has advanced not only the knowledge of physiological psychology but also of vocational guidance and selection by developing clear cut ideas as to the degree of general intelligence and special traits necessary for the different occupations. In 1914 Woolley and Fischer stated in their book 'Mental and Physical Measurement of Working Children '—' At least one good way of testing the usefulness of Experimental Psychology as a guide in vocational advising, is to apply a representative series of psychological tests to a large and fairly homogeneous group of young people and then find out how much, if any, correlation exists between the outcome of the tests, and industrial success or failure in various directions.'—This is now corroborated with good results. *In vocational guidance, the Labour and Industries department of the government join hands with school authorities and guardians.*

TESTS.

A thorough intelligence test is made to ascertain the inborn intellectual calibre of the boy or girl; his or her physique is tested very critically to discover the degree of strength or weakness of different systems in the body. The Home Report and the School Report are considered along with the assay of the physique and natural intelligence. After this, some of the performance tests and vocational tests are applied to find out the direction in which the boy's or girl's activities may fittingly be directed. Psychologists have almost succeeded in estimating not only the degree of intelligence but also other necessary qualities of talent, character and personality traits necessary for different avocations. Vocational guidance is fast becoming amenable to the researches of psychologists and it is very likely that within the next ten years the matter would be attaining a stage of enhanced practical applicability. *The emergency requires that universities should frame regulations for appointing for every school one medical man and a psychologist thoroughly trained in Experimental Psychology and Psychoanalysis to conduct periodical examination of the physical and mental health of every boy or girl in the school with a view to formulating remedial measures.* You know that practically nothing is being done in the provinces by the Education and Industries departments, schools, corporations, and universities in India. But time is ripe for these bodies to wake up from their slumber. It will take an extensive application of intensive methods at least 10 years to bear fruit.

VOCATIONAL SELECTION.

Vocational selection by the different interested bodies is being practised with much greater success. In this connexion

I recommend to you the Reports and various monographs of the Industrial Health Research Board of the British Government and the publications of the National Institute of Industrial Psychology in Great Britain which has been doing excellent work for the last 13 years in England under the guidance of the great practical English psychologist, Dr. C. S. Myers and the Foreword to the White House Conference in the United States of America on Vocational Psychology. You know what a waste of money, energy, and time is suffered by students of Engineering and Medical institutions in India. Only after years of study they find out that they ought not to have selected the training for the course in which they failed. Of those who ultimately pass out, the majority do not possess the temperament and traits necessary for the profession for which they have qualified, and are too old to try another. Nearly the career of 80% of such lads or girls is blasted for ever. They fritter away their energy and health and their parent's savings to no purpose. If you look into the condition of the scholars who prosecute their studies beyond the Matriculation stage you will find that 95% of them have no aim in life. They drift along the wave of circumstances without any help from any quarter only to dash against the solid rock of fate. They become discontented and bitter in life and form an important factor in undesirable political upheavals. Of this class a large section passes through a course of training in law and politics imbued with high ambition which is very seldom realized. *It is, therefore, absolutely necessary that the authorities concerned in the training of all sorts of technical professions should realize their responsibility and seek to make a proper selection from amongst the candidates by the application of psychological tests.*

INDUSTRIALISM AND ITS EFFECTS ON THE PEOPLE.

The growth of industrialism with the springing up of factories and mills all over India, crushing cottage and indigenous industries, has disturbed the avocations of the people, hitherto organized on a basis of hereditary professions—the Castes. It has raised the standard of living and has kindled ambition in the masses so much so that there has been a distinctly increasing demand for ease and convenience on the part of the work people in the shape of shorter working periods and higher wages putting the management into perplexing situation. The capitalist and the workers have often come to a clash and there have been serious strikes and lock-outs.

LABOUR CONDITIONS IN THE PAST.

Human nature is always human nature. There were disputes between master and labourer in India in the past.

It may not be out of place to mention here that in India long before the Factory Act came into operation, child labour below 8 had been severely punished. Provisions existed for the capitalist's being made liable to payment of wages to workers in weaving factories if they were asked to work during public holidays scheduled by the government or on festive occasions. Again, if the capitalists combined to bring about a lowering of wages, they were punished severely. As far as the Royal Household and State-owned factories were concerned, the wages and allowance of food were prescribed by the State. Wages were on contractual basis in the open market. Disputes between capitalists and workers were settled by experts. All these are recorded in Kautilya's 'Arthasāstra'.

THE SLOGAN OF THE INDUSTRIAL PSYCHOLOGIST AND THE OLD FALLACY.

In the West, psychologists have appeared on the field and have demonstrated to the capitalist and the heads of factories and mills that *a contented work people is the soul of industry* and that *it is a mistaken policy to conceive that longer periods of work will produce larger output. Overtimes are wasteful.*

AIMS AND OBJECTS OF INDUSTRIAL PSYCHOLOGY.

The object of Industrial Psychology is to increase the output of industries by improving the working conditions of the labourer, by reducing factors of fatigue and accidents and providing for a method of selecting the proper type of men and gradually weeding out the misfits. In short, the programme is for the stoppage of the waste of human labour which is so rampant everywhere, the people not knowing it for want of a trained eye.

METHODS.

EXPENDITURE ON CONVENIENCE OF WORKERS IS NO LOSS TO THE FIRM.

This new branch of psychology utilizes also the principles of the physical and biological sciences and specially of physiology in improving the working condition of the labourers and their physical and mental health. The Industrial Psychologists pay attention to the environmental conditions of lighting, heating, ventilation, smoke, air movement, and noise. They not only look to the sanitary condition of the surroundings where people work but make it a point to reduce all possible inconveniences due, for instance, to the insufficiency or intensity and shine of light, smoke, dust, uncomfortably high temperature of the room and distractions due to high noise-intensity. They have proved that all the above conditions result in diminution of possible output. The posture of the worker. disposition of things and tools, routes for carrying goods and the bad construction of implements do not escape their attention. *They try to impress upon the management that every convenience granted to the worker in the factory is no waste of money but earns more in the long run. Improvement in working condition reduces labour turnover.* They try to reduce cumulative fatigue and monotony by shortening the total working hours of the day, shifting the tiffin to proper place, and introducing rest pauses at suitable moments. They have found out that accidents in a factory are largely and frequently suffered by a small group of workers, now recognized as accident-prones.

THE INDUSTRIAL PSYCHOLOGIST AND THE MANAGEMENT.

Tests have been devised for ascertaining accident-proneness of a worker so that he may be shifted to positions where chances of accident are very small. They do not stop here. The Industrial Psychologists come to intervene with suitable tests for the selection of people suitable for a particular job, and have formulated schemes of training for the selected for fitting them to the job. They have much to say in every detail of work that goes on in a factory or workshop. *The Industrial Psychologists do not want to supplant the business of the Manager or the Engineer or the Foreman or the Factory Inspector on behalf of the Government as the spokesman and guardian of the labouring class.* They have something to say for the benefit of the industry before the situation reaches such conditions in a factory that they are pronounced 'bad' by the Factory Inspector. They have a definite plan of helping both the capitalist and the worker. Industrial Psychologists have been able to increase the output of factories by reducing the hours of work without reducing the number of men, thus demonstrating the possibility of diminishing the cost of production.

CONDITIONS IN THE WEST AND IN JAPAN.

In America, France, Belgium, Germany, and Russia, almost all the important factories have a psychological staff with their laboratories distinctly apart from their 'welfare or personnel' departments. A division of applied psychology was added to the Carnegie Institute of Technology in 1915. This is now known as Division of Co-operative Research, which conducts also surveys for other individual firms. The Psychological Corporation, The Personnel Research Federation, The National Research Council are well-known bodies which have been doing such work in America. In Germany in the year 1916 fourteen centres were engaged on Industrial Psychological problems.

The Railway, Tramway, and Electric companies made their selection of workers with the help of their own laboratories. As far back as 1922, 22 large concerns in Germany possessed their own psychological laboratories. 'In July 1926 there were listed over 100 firms which were applying psychological methods in selection. These included Krupp, Carl Zeiss, Allgemeine, Elektrizitätsgesellschaft, Siemens Co., Helske, Loewe Co., Osram, the State Railways, and the Greater Berlin Tramways.' There are various laboratories in the different cities and in different governmental departments such as Post Office and Telegraph service, where research departments have been organized. Nearly a dozen big psychological institutes of applied or practical psychology are in existence in Germany and you are all aware of the advanced industrial condition in that country.

In England, perhaps the most conservative of the Western nations, there are two organizations, one distinctly a Government limb—The Industrial Health Research Board—and the other a private organization for research and rendering actual help and offering advice as expert body to individual factories or workshops on payment of fees, viz. the National Institute of Industrial Psychology. The latter charges fees but that is for the maintenance of the Institute and research and the fees do not go to individual pockets as profits. The British scheme appears to be quite economic. The existence of the National Institute which serves the needs of all industries, factories, and firms big and small seeking its aid, obviates the necessity of multiplying and maintaining laboratories and staff throughout the year, by individual firms. The Institute frequently co-operates with the Government Medical Research Council, especially the Industrial Health Research Board in the investigation of important problems of industrial psychology, vocational guidance. It has conducted more than 200 investigations in different factories, mills, workshops, railways, mines, and business firms with considerable success. About a year ago it was engaged in investigations in one of the Kolar Gold Fields in India. From the communications I have had with them, I can tell you that the National Institute of Industrial Psychology is eager to extend its activities in India. In Japan there is a psychological department attached to the State Railways and the head happens to be also a psychoanalyst.

The Government, the factory-managers, the mine-owners and employers of large numbers of people at a place, do not keep much information of what is being done in the West to utilize the benefits of Psychology and Physiology in every possible aspect of industry.

From all these you will agree that there is a crying need for its application in India. Expert knowledge of Psychology is nothing unless it can be brought to the service of mankind. But the problem is a colossal one and cannot be tackled without the help *and co-operation of the Government, the Railways and the different industrial concerns of the country.*

FIELD FOR WORK.

I cannot pass on without recording my indebtedness to the management of the greatest Iron and Steel Works in India at Jamsedpur for offering me opportunities of studying their plants and men from the psychological standpoint. The management is imbued with the most up-to-date and progressive ideas almost in every direction. The housing schemes, education arrangement for the boys and girls of workers and the inhabitants, the welfare department, employment bureau, the safety and first aid organization, and the hospital for the workers and the general population seemed in no way inferior to those possessed by industrial concerns in Europe and America. There is an elaborate scheme for the training of Indians for filling up different jobs in the Works. They are quite in keeping with the position of the largest Steel works in the East as also in the British Empire—nothing remaining to be desired. For all these the Indian Board of Directors deserve nothing but praise. In fact the management can be charged only on two counts. There is lack of any system of giving publicity to what they are doing for the industry, the workers and the big colony which has gradually grown up and which they are managing. I could not find any Psychological Laboratory in the Works nor any scheme of Psychological selection for recruitment of future staff—when they number more than 20,000 men but I may tell you from the talk I had with the management that a psychological selection of the staff will be given a trial in the future. I should like to see that greater attention of the authorities be directed in the matter of further improving the environmental conditions of the worker. Recent advances in Industrial Psychology may be of considerable help in minimizing the distractions at the spot of work. This is no place or occasion to give you the result of my preliminary investigation. In separate papers these matters have been dealt with. Though the conditions that I met with were quite satisfactory, I have not the least doubt that the output can further be increased by the application of the principles of Industrial Psychology. The same remark would apply to the factory of the Bengal Chemical and Pharmaceutical Works and I am proud to say that I had some hand to conduct first experiments in Industrial Psychology with their help. I worked for some time first at the Bengal Chemical and Pharmaceutical Works and then at Tata's Steel Works and enjoyed their hospitality. These are the managements who readily responded to my proposal. I think there are others who will grant a preliminary investigation if they are convinced of the utility of the scheme. After mature consideration I have come to think that *industrial concerns may take the aid of Psychology first by the introduction of Psychological selection for the recruitment of the future staff and then gradually removing all sorts of inconveniences of the work people.*

I hope you will agree that necessity exists for Vocational Psychology and selection and for Industrial Psychology. Great possibilities await in these directions for work which is very likely to result in ample rewards in the improvement in industrial and economic conditions and solutions of the problems of unemployment and unrest. If trained students of Psychology are properly guided in tackling these problems, there is every chance of the discovery of important psychological truths. There is a vast field for very urgent and useful work but the zeal of the authorities has to be roused and funds found.

ALL INDIA INSTITUTE OF APPLIED PSYCHOLOGY.

There are in India at the present moment three or four psychological laboratories and one laboratory of Experimental Psychology only. Of these the oldest and the biggest is that belonging to the Calcutta University in the College of Science. This can be made a nucleus to which an All-India Institute of Applied Psychology can be tackled and I may give you the suggestions for the outlines of a scheme, the details of which I have worked out; these can be supplied if the government and the universities respond.

In the projected Institute there may, for the present, be opened the departments of (1) Industrial Investigation, (2) Personnel Work, (3) Vocational Guidance, (4) Child and Educational Clinic, and (5) the Psychiatric and Psychoanalytic Clinic.

In course of time, of course, the Institutes of Industrial Psychology and Vocational Guidance will have to be organized in the different provinces in which the Education and Industries departments of the Government, the universities, the school authorities, and the corporations should co-operate *but time is ripe for at least one full-fledged Institute of Applied Psychology for the investigation and research of the various problems awaiting solution.*. The Institute will be a scientific association for the application of the findings of modern Psychology and Physiology to every aspect of human life and its aims and objects may be set forth as follows :

AIMS AND OBJECTS.

1. *Testing of Intelligence, Character, Personality, and Talents* with a view to ascertaining the normality of the progress of the child or the adolescent, to formulate remedial measures, if possible, for backwardness, educational and charac-

ter difficulty, delinquency, inhibition, proneness to mental disorder, etc.

2. To give *vocational guidance* for the choice of careers and hints for *vocational training* to boys and girls. To formulate specific tests and help the authorities in different professional lines, technical institutions, workshops, railways, telegraphs, mines, factories, mills, and industries in the selection of suitable candidates and the weeding out of misfits.

3. *Application of Industrial Psychology and Physiology* to various business firms, industries, workshops, factories, spinning mills, mines, etc., for better out-turn, smooth working, prevention of accidents, strikes, and lock-outs.

4. To co-operate with the Police and jail authorities, borstals, and reformatories for the *detection of psychological causes of criminality with* a view to their correction and improvement of mental outlook of the would-be criminal and recidivist. To help the Police in the *granting of licence* to drivers of motor-cars, lorries, and tramcars with a view to checking accidents, after proper psychological tests.

5. To provide facilities to those, who deal with crime, criminal and criminal justice for a clearer understanding of the *psychology of crime* with a view to minimizing the chances of miscarriage of justice.

6. To co-operate with factory inspectors for the improvement of industrial-psychological conditions in factories.

7. To co-operate with the Indian Psychoanalytical Institute, Mental Hospitals, and Observation Wards in the treatment of mental disease.

8. To conduct psychological enquiries into the *causes of political crimes* in co-operation with the prison authorities and the public and formulate remedial measures for its eradication.

9. To conduct original research and arrange public lectures, radio talks, etc., for the dissemination of psychological principles on every aspect covering the mental life of individuals and groups.

Section of Psychology.

Abstracts.

1. A note on the chronaxy values of antagonistic muscles, with suggestions for an improved response-key.

S. S. Jalota, Calcutta.

The paper is based on some fourteen hundred readings taken while performing experiments on the relative chronaxy values of the antagonistic muscles. French experimenters have reported significant differences. The author also recorded these, until an improved response-key was designed, resulting in the practical elimination of the significant differences.

The paper suggests necessary modifications of the response-key for recording 'release pressure' or extensor reactions, and points to the necessity of adequate apparatus for experiments in psychological research.

2. Adult education in India.

N. G. Apte, Poona.

From the very early stages of the present system of education in India under British regime, education has come to conventionally mean literacy. In the early part of the new regime knowledge of the English language was supposed to be the best education. This was so far as the few townsmen were concerned. The question of the village was almost left untouched. From author's point of view the city people cannot be called educated as education should give them productive capacity, intelligence, higher moral standard, greater civic responsibilities, and such other useful acquirements. The present Arts colleges give students only literacy which is only useful to turn out clerks and readers. The case of literacy in the villages is altogether different. Most of the older village adults are 'illiterate', i.e. unable to read or write English or some Vernacular and it is this class that has to be educated. It is these adults who really represent the country and every attempt has to be made to coach them up. Attempt to produce wholesale literacy has failed in their case as is evident from villages where primary schools have been conducted for over fifty years without the desired result. Demonstration and practical lessons are the best means of education, but are out of reach of the country at present and for long time to come. Lectures, Purans, and Kirtans do give some education restricted to moral and mental development. Material education could only be given successfully by means of magic lantern slides where one can get the advantage of pictures and speech both. This is made easier by the preparation of a small box-shaped lantern to be worked by a 300 c.p. petromax lamp. Such an outfit is portable and gives a fairly good picture on the screen. This has been specially designed for village work by the Poona Adult Education League.

3. Research in education—technique and problem.

D. D. Shendarkar, Hyderabad (Deccan).

Importance. Will develop technique of teaching and professionalize the teacher's calling.

Characteristics. Seeks generalizations based on observed facts. Steps involved in research. Education as Science. Pure Vs. applied research.

Scope. Not limited to experimentation. Includes studies in history, sociology, philosophy, administration and organization of education, curriculum, learning, teaching methods, and educational apparatus.

Selection of problem. Sources of problems are class-room difficulties and previous studies. Problem should be precisely defined.

Technique of experimentation. Experiment involves setting up of controlled situation to examine the operation of a variable factor. Methods—one group, equivalent groups and rotation groups.

Collection of data. Data are objective items collected for evaluating hypotheses. Methods—observation, questionnaire, interview, test and case study.

Analysis and classification of data. Application of statistics. Not a substitute for original data and analysis of variable factors.

Pitfalls. Errors in respect of problem or technique.

Organization. Organization in United Kingdom, Australia, U.S.A., and India. Recommendations: Research degrees at University; Psychology section of Science Congress to include Educational Science; Institute of Education, Functions—training, library, research journal and facilities for research.

4. Child psychology—play and project.

(MISS) S. GHOSH, Mayurbhanj.

Instinct of play is most prominent among children. It is itself a sublimation. Project method is the only means through which play instinct can be fostered and developed.

5. Preliminary psychological investigations in the factory of the Tata Iron and Steel Co., Ltd.

M. N. BANERJI, D. GANGULY, *and* S. C. BANERJEE, Calcutta.

As a result of investigations possibilities of improvement in output and reduction of unnecessary fatigue are indicated.

6. Preliminary psychological investigations in the factory of the Bengal Chemical and Pharmaceutical Works.

M. N. BANERJI, J. C. BANERJI, *and* P. C. BANERJI, Calcutta.

As a result of investigations possibilities of improvement in output and reduction of unnecessary fatigue are indicated.

7. Tactual illusions.

K. C. MOOKHERJEE, Dacca.

This paper contains observations on some cutaneous illusions hitherto unobserved. An attempt has also been made to explain them physiologically on the law of irradiation.

8. Reactions of gold fish to colours.

NIRODAPROSAD MUKERJI, Calcutta.

Object of the experiment. Colours chosen. Psychological principal of colours. Method followed. Results obtained. How far they agree with standard results. The drawbacks of the method followed. Next series of experiments already begun. Results to be communicated later.

9. A preliminary report on the training of a defective child.

M. Samanta, Calcutta.

A new enterprise in this country. The methods adopted in Western countries are modified and made suitable for their application here. Other novel means are applied with much effective results.

10. 'Reaction Time' as an indicator of onset of fatigue.

M. N. Banerji *and* S. N. Banerji, Calcutta.

Based on the investigations carried out at Tata Iron and Steel Co., Ltd., Jamshedpur, in five production plants on 300 workers in the different shifts. The results point to the Chronoscope being superior to the Dynamometer.

11. Vernier chronoscope and dynamometer.

M. N. Banerji *and* R. Ghosh, Calcutta.

New experiment in the laboratory to test the utility of the apparatus in fatigue study.

12. Staring.

R. Ghosh, Calcutta.

Staring by a man at a woman is decidedly a sexual phenomenon. Staring by an unacquainted young man at a woman is resented by the latter. This feeling of offence is more common with unmarried aged girls, who are said to be sex-conscious. The sex-appeals even in meaningful starings have been overlooked by married women. As to the offensive nature of staring at opposite sex the author proposes a hypothesis which is explained in the paper. The author cites some illustrations in support of his hypothesis. In concluding remarks, the author defines four stages in the staring, which are as follows :—(*a*) The arousal of sexual desire through the appreciation of the sex-appeal, superimposed on or originally present in the staring. (*b*) The simultaneous thought of the social bars. (*c*) The desire failing in its satisfactory nature. (*d*) Feeling of irritation owing to the perpetuation of Psycho-sexual-tension in the one who is stared at.

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N

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Shrivastav, Chandra Prakash, Allahabad University, Allahabad.

Shrivastav, Mathura Prasad, Allahabad University, Allahabad.

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Sinha, Badri Narayan, Allahabad University, Allahabad.

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Wagh, P. V., M.Ag., Assistant, Sugar Research Scheme, Padegaon, P.O. Nira, Poona.

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Acharya, B. N., B.Sc.
Agrawala, J. P., B.Sc.
Apte, M. T.
Apte, M. V., B.Sc., M.B.B.S.
Athaye, K. S.
Atrishi, B. N.

B

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Bhargava, Hari Raman.
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Borgaonkar, S. S.

C

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Chiplonkar, M. W., M.Sc.
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Contractor, Sohrab, J.

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Gulati, K. C.

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Ichaporia, M. B.

Irani, F. D.
Irani, J. D.
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Jawalkar, D. G.
Joshi, C. B., B.Sc.

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Kalyani, V. V.
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Kelkar, G. R.
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Limaye, R. V.
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Mukerjee, Bhupendra Nath.

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Nadarajah.
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Narasaiya.
Natesan, A. A.

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Oak, V. S.

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Panikkar, K. M.
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Pasha, Syed Ameen.
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Patel, N. M.
Patil, B. V.
Pereira, B. F., B.Sc.
Pereira, H. C.
Periyan, Victor.
Phadke, N. H.
Pinto, F. Maxi.
Prabhu, Y. K.
Pradhan, L. B.
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Pundalik, S. K.
Puri, Vishwambhar.

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Rampal, C. L.
Rangwalla, Y. I.
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Rao, C. Anandarama.
Rao, C. R. Narayan.
Rao, K. D.
Rao, M. V. Sheshagiri.
Rao, P. Ramchandra.
Rao, P. R. Ramchandra.
Rao; P. S.
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Rawal.
Rege, P. S.

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Singham, J. Vanni.
Sinha, B. B.
Solanki, Dhirajlal V.
Solomon, Samuel, B.Ag.
Soparkar, R. M.
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U

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Wadhwa, P. R.

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Zakiuddin, M.

RULES.

INDIAN SCIENCE CONGRESS.

1. The name of the Association shall be the Indian Science Congress, and its object shall be the advancement of Science in India by the annual holding of a Congress and the doing of all such things as are incidental or conducive to the above object, including :

- (*a*) the holding and management of funds and property,
- (*b*) the acquisition of rights and privileges necessary or convenient for the object of the Association,
- (*c*) the management, development, improvement, disposal, and sale of all and any parts of the property of the Association.

2. There shall be an Executive Committee which shall carry on the administrative work of the Congress and submit such questions as it thinks desirable to a General Committee at its Annual Meeting during the Session of the Congress or at a Special Meeting of which due notice shall have been given.

3. The Executive Committee shall consist of the President, the Retiring President, the two General Secretaries, and the Treasurer (who shall be the Treasurer of the Asiatic Society of Bengal for the time being) of the Congress, the General Secretary of the Asiatic Society of Bengal for the time being, and five Permanent Members elected by the General Committee at its Annual Meeting during the Session of the Congress.

The Executive Committee shall co-opt as members at least one and not more than two Local Secretaries for the ensuing Session of the Congress.

4. The Executive Committee shall have full power to transact all business in case of emergency, notwithstanding any limitations hereinafter laid down, and to deal with all matters not otherwise provided for in these Rules, including the making of such Regulations as may appear conducive to the good administration of the Association and the attainment of its object; provided always that such Regulations be not inconsistent with anything contained in these Rules, that they be reported for the information of the next meeting of the General Committee, and that they be subject to rescission or alteration by the Executive Committee or by any meeting of the General Committee.

5. There shall be a General Committee which shall consist of all Permanent Members of the Congress and such Sessional Members as have held office in the Congress.

Officers of the Congress for the purpose of this Rule shall be: the Members of the Executive Committee and the Presidents and Recorders of Sections.

6. The General Committee shall meet at least once during each Session of the Congress, preferably in the middle of the Session.

7. There shall be a Council which shall consist of the Members of the Executive Committee, the Past Presidents of the Congress present in India, the Sectional Presidents for the ensuing Session, and, in addition, five Permanent Members elected by the General Committee at its Annual Meeting during the Session of the Congress.

8. The Executive Committee shall consult the Council on matters of general scientific import and policy.

9. There shall be a President who shall be nominated by the Executive Committee, and whose nomination shall be submitted to the General Committee at its Annual Meeting during the Session of the Congress for confirmation.

10. There shall be two General Secretaries who shall be nominated by the Executive Committee and whose nomination shall be submitted to the General Committee at its Annual Meeting during the Session of the Congress for confirmation.

11. Each General Secretary shall hold office till the termination of the fifth Session of the Congress following the confirmation of his appointment, and shall be eligible for re-appointment.

12. In the event of a vacancy amongst the General Secretaries occurring between two Sessions of the Congress the Executive Committee shall have power to appoint a General Secretary for the period up to the termination of the next Session of the Congress.

13. There shall be a Local Secretary or Local Secretaries for each Session of the Congress who shall be appointed by the Executive Committee.

14. There shall be a Local Committee for each Session of the Congress which shall be appointed by the Executive Committee.

15. The Local Secretary, or Secretaries, and the Local Committee shall jointly, on behalf of and in consultation with the Executive Committee, make all necessary arrangements for the holding of the Session of the Congress.

16. For the purpose of scientific deliberation during the Session of the Congress there shall be such Sections corresponding to different branches of science as may from time to time be constituted by the General Committee on the recommendation of the Executive Committee.

17. There shall be Sectional Presidents and Sectional Recorders who shall be appointed by the Executive Committee.

18. There shall be Sectional Committees which shall consist of the following two officers :—

(*a*) The President of the Section (Convener),
(*b*) The Recorder of the Section,

and, in addition, of the following members :—

(*c*) All Permanent Members of the Congress who have been President or Recorder of the Section concerned,
(*d*) Two members elected by the General Committee at its Annual meeting during the Session of the Congress.

A Sectional Committee may co-opt two additional Permanent Members of the Congress of whom one at least shall be resident in the locality in which the ensuing Session of the Congress is to be held.

In the absence of the President of any Section from any of its meetings, the most senior member of the Sectional Committee present shall take the Chair.

The Sectional Committee shall meet on the opening day of each Session of the Congress and as often as may be necessary during the Session of the Congress.

Each Sectional Committee shall in its meetings during the Session of each Congress :—

(*a*) nominate a Sectional President and a Sectional Recorder for next year's Session of the Congress for the consideration of the Executive Committee,
(*b*) determine the detailed arrangements of the Sectional meetings,
(*c*) select the papers to be read and discussed
(*d*) delete by a two-thirds' majority any abstract from final publication in the Proceedings,
(*e*) determine the contents of the Sectional record in the Proceedings.

19. (*a*) Any paper submitted for reading at the Session of the Congress shall be forwarded to the President of the Section concerned so as to reach him not later than a date to be fixed from time to time by the Executive Committee.

(*b*) Any paper submitted for reading at the Session of the Congress shall be accompanied by an abstract in triplicate.

(*c*) Any paper submitted for reading at the Session of the Congress shall be refereed by the Sectional President or by some person or persons appointed by him. Decisions with regard to acceptance or refusal of any paper for submission to the Sectional Committee shall be final and all reports confidential.

(*d*) No published paper shall be accepted.

20. The Congress shall consist of four classes of members :—

(*a*) *Permanent Members.*
Annual subscription Rs. 10/-.
The subscription shall become due on the 1st of February of each year and shall only be effective as a payment for Permanent Membership subscription if paid before the 15th of July of the year.

(*b*) *Sessional Members.*
Subscription Rs. 10/- per session.

(*c*) *Associate Members.*
Subscription Rs. 5/- per session.

(*d*) *Student Members.*
Subscription Rs. 2/- per session.

(A Student Member must be duly certified by the head of his institution to be a *bona fide* student.)

Permanent and Sessional Members shall have the right of contributing papers for reading at the Session of the Congress and to receive free of charge all publications relating to the Session for which they are members.

Associate and Student Members shall have the right of contributing papers for reading at the Session of the Congress provided they have been communicated by a Permanent Member.

21. Any Permanent Member may compound for the payment of all future annual subscriptions by the payment in a single sum of Rs. 150/-.

22. The following procedure shall be observed for the making of any addition to or alteration in the Rules of the Indian Science Congress :—

(*i*) Proposals for additions to and alterations in the existing Rules of the Indian Science Congress may be placed at any time before the General Committee by the Executive Committee.

(*ii*) (*a*) Proposals for additions to and alterations in the existing Rules by any Permanent Member of the Congress shall be sent to one of the General Secretaries so as to reach him two full months before the meeting of the General Committee in which they are to be moved.

(*b*) One of the General Secretaries shall circulate such proposals to all Permanent Members of the Congress at least one full month before the meeting of the General Committee.

(*c*) Any amendments to the proposals shall be sent by any Permanent Member of the Congress to one of the General Secretaries so as to reach him at least a fortnight before the meeting of the General Committee.

(*d*) The proposals together with any amendments, shall be brought up before the meeting of the General Committee at its Annual Meeting during the Session of the Congress together with any remarks of the Executive Committee and declared carried if accepted by a two-thirds' majority of the constituent Members present at the meeting.

(*Adopted the 5th January,* 1931.)

ACCOUNTS.

I.

Account of the Indian Science Congress for the year ending the 31st December, 1933.

RECEIPTS.	Rs.	A.	P.	EXPENDITURE.	Rs.	A.	P.
To Balance	19,263	7	2	By Printing	5,963	6	6
,, Life Membership Fees	290	0	0	,, Bonus to Society's staff	600	0	0
,, Subscriptions ..	4,748	12	6	,, Donation to 'Current Science' ..	250	0	0
,, Subscription received from Local Secretary, Patna	729	0	0	,, Advance for travelling expenses to General Secretary of the Congress ..	500	0	0
,, Subscription received from Local Secretary, Bangalore ..	1,929	10	0	,, Postage	569	9	3
,, Interest on Fixed Deposits	310	9	0	,, Contingencies ..	36	10	0
				,, Balance (including deposit outstanding Rs. 14,998-12-3) ..	19,351	12	11
TOTAL ..	27,271	6	8	TOTAL ..	27,271	6	8

K. C. MAHINDRA,
Honorary Treasurer,
Asiatic Society of Bengal.

II.

INDIAN SCIENCE CONGRESS, BOMBAY, 1934.

Statement of Local Accounts.

RECEIPTS.	Rs.	A.	P.
To Contribution handed over by the Local Committee in Poona	3,356	8	0
,, Contribution collected in Bombay:			
Reception Committee :—			
(i) Vice-Patrons	1,050	0	0
(ii) Donors	550	0	0
(iii) Members	1,760	0	0
Full Members	1,468	0	0
Associate Members	408	0	0
Student Members	214	0	0
,, Exhibition	300	0	0
,, Excursions	787	11	3
,, Advertisements (Secured in Bombay)	230	0	0
Carried over	10,124	3	3

EXPENDITURE.	Rs.	A.	P.
By Printing :—			
Bombay-Poona	1,622	9	0
List of Members	335	0	0
Programme of the Congress	285	0	0
Programme of the Soiree	27	0	0
Excursion Supplement and tickets	192	10	0
Volunteers' Badges (Officers)	37	8	0
Delegates and Volunteers' badges	39	1	0
Office printing and stationery	288	6	0
,, Lecture Rooms Equipment, etc. :—			
Hire of chairs in the University Hall	314	0	0
C. J. Public Hall charges	74	0	0
Miscellaneous (including breakages, etc.)	62	13	0
,, Excursions :—			
Poona-Bhor-Khopoli	425	10	3
B.E.S.T. buses	308	0	0
Miscellaneous	10	2	0
,, Volunteers' contingency expenses	45	5	3
,, Household Service (Sweepers, etc.)	48	10	6
,, Reception Room and Inquiry Office	37	11	6
,, Office :—			
Telephone hire	60	0	0
Typewriter hire	30	4	0
Clerk	100	0	0
Peon	40	0	0
Postage	141	2	0
Miscellaneous	13	2	0
Carried over	4,537	14	6

RECEIPTS.	Rs.	A.	P.	EXPENDITURE.	Rs.	A.	P.
Brought forward ..	10,124	3	3	Brought forward ..	4,537	14	6
				By Entertainments :—			
				Reception Committee's At Home ..	650	0	0
				Party to Volunteers by the Committee ..	180	0	0
				Miscellaneous ..	54	0	0
				„ Gratuities to workers including Laboratory Assistants, Lantern Operators, Hamals, Peons	161	8	0
				„ Musical Soiree (excluding printing) ..	100	0	0
				„ Miscellaneous (including expenses on conveyances and other contingencies) ..	132	10	9
				„ Amount sent to Indian Science Congress Association, Calcutta :—			
				Sale of Members' tickets ..	2,090	0	0
				Sale of tickets to Members of the Reception Committee at Rs. 10 each	580	0	0
				„ Cash in hand with the Local Secretaries for future expenses ..	200	0	0
				„ Balance (Surplus amount deposited with the University of Bombay)	1,438	2	0
TOTAL ..	10,124	3	3	TOTAL ..	10,124	3	3

BOMBAY,
28*th February*, 1934.

M. R. KAPADIA,
Hon. Treasurer.

V. R. PATWARDHAN,
Hon. Auditor.

S. L. BHATIA,
P. R. AWATI,
Hon. Secretaries.

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31.8.62		
27.12.62		
17-12-93		